ORKNEY'S FIRST FARMERS

Reconstructing biographies from osteological analysis to gain insights into life and society in a Neolithic community on the edge of Atlantic Europe.

Volume 1 of 2

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ABSTRACT

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For since by man came death,

by man came also the resurrection of the dead.

1 Corinthians 15:21

"There's Treasure Everywhere." (Watterson 1996:44).

(This project takes the position that analysis of human remains will be particularly informative to understanding the British Neolithic but has historically been underexploited. There is treasure buried in museums everywhere.)

Keywords:

Neolithic, Society, Disease, Diet, Trauma, Belief, Activity, Osteology, Agriculture, Violence

ABSTRACT

There has been historical failure to exploit skeletal data in archaeological syntheses of the Neolithic, compounded by poor or cursory osteological reports. This project aimed to discover what Neolithic Orcadian life was like, arguing from skeletal evidence.

Orkney's exceptional site preservation and large skeletal collections present opportunities for detailed analysis. The Orkney environment presented identifiable constraints to Neolithic lifeways. Isbister chambered cairn produced the largest assemblage of human remains from any single British Neolithic site. This was examined alongside other Neolithic collections to discover evidence for, and develop models of Neolithic life.

The demographic structure indicates that twice as many adult males were deposited as females. Few young infants were in the assemblage but disproportionately many older children and young adults. Stable light isotope analysis suggested age and sex-related dietary differences with a predominantly terrestrial protein source. Pathological conditions included scurvy, multiple myeloma and osteoarthritis. Trauma and non-specific lesions were common and affected all age and sex groups. Prevalences of pathological conditions seemed high and may reflect a group selected for some reason related to disability or deformity. The interred individuals probably held some special status within their society. The chambered cairns' commingled bones do not indicate an egalitarian society or contemporary ancestor veneration but suggest monumental tombs had some special role possibly related to violent death or supernatural liminality.

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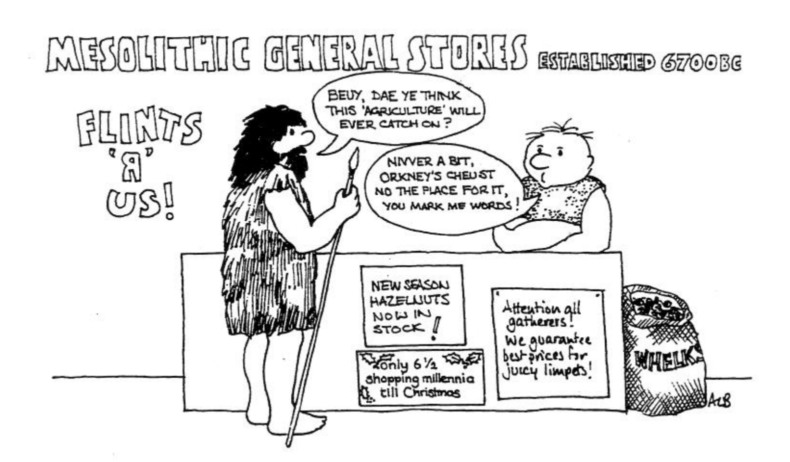

Cartoons by Anne Brundle: L, on her mother's hip replacement; R, on the Neolithic transition.

Theya Molleson has always been encouraging and it was on her sound advice that I studied the Isbister collection. Chris Knüsel is an inspirational teacher. His help and advice have been given generously and gratefully received, from the earliest stages of this project onward. Julia Lee-Thorp has been a great support: I have especially appreciated her gentle but firm guidance and efforts towards finding unpublished work. I have been privileged to know Steve Dockrill and Julie Bond over many years. Their fieldwork and archaeological understanding have consistently given me much to aspire to and their advice and friendship are gratefully acknowledged.

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During this project I have shared lab. space with a large number of colleagues, discussions with whom were a source of interesting or useful comments and excellent advice. I would particularly like to thank Rebecca Crozier (Queen's University, Belfast) and Julia Beaumont (University of Bradford) in this regard but also Rick Schulting (University of Oxford), Don Brothwell (York University), Fiona Tucker (University of Bradford), Meg Hutchison (Marischal Museum, Aberdeen) and Maura Pellegrini (University of Bradford). Other people whose advice and conversation have been valuable include Nick Card (ORCA), Alison Sheridan (NMS), Nigel Melton (University of Bradford), Chris Walmsley (University of Bradford), Merryn Dineley and John Hedges. Mark Pollard and Rick Schulting kindly provided unpublished and prepublication data.

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CONTENTS VOLUME 1

excavation practices. A brief statement of method then leads into more detailed thematic discussions in the following chapters.

The methods employed were divided into two major elements, each of which is described separately. The first and more fundamental part was a detailed macroscopic analysis, which provided essential data that are presented as a succession of basic themes. The derived demographic and palaeopathological details were used to inform the subsequent sampling strategies.

(Please note that section 3.6 is split between Volumes 1 and 2, at page 341.)

CONTENTS VOLUME 2

CONTENTS of CDROM

LIST OF FIGURES

LIST OF TABLES

List of Abbreviations Used

A	Adult
ABDUA***	Marischal Museum accession number prefix
bc	'Before Christ,' used to denote uncalibrated radiocarbon dates
BC	As Above but a known or calibrated radiocarbon date
	or 'Bone Context' (an existing locational prefix: BC...)
bp	'Before Present' (uncalibrated radiocarbon years before 1950)
BP	As above, calibrated
BSR	Banks, South Ronaldsay, used as a prefix for the tomb finds
BSR(***)	Bone fragment reference number from Banks, South Ronaldsay
BSR/***\	Special find number from Banks, South Ronaldsay
c	*circa*
C	Child
DJD	Degenerative Joint Disease
DNA	Deoxyribonucleic Acid
F	Female
IS***	Cataloguing prefix for Isbister
IS(***)	Bone fragment reference number from
IS[***]	Sample number assigned for Isbister (in Hedges 1983)
J or Juv.	Juvenile
L	Left Side
M	Male
MD	Medical Doctor
MNI	Minimum Number of Individuals
MoW	Ministry of Works

MP	Member of Parliament
MSM	Musculoskeletal Markers
MTN	Minimum Total Number (same as MNI)
NMAS	National Museum of Antiquities of Scotland
NMS	National Museums, Scotland
N	No
n	number
NoSAS	North of Scotland Archaeology Services
OA	Osteoarthritis
OAT	Orkney Archaeology Trust
OD	Osteochondritis dissecans *or* Ordnance Datum
OIC	Orkney Islands Council
ORCA	Orkney Research Centre for Archaeology (Orkney College)
P	Probability
PA	Psoriatic Arthritis
PPS	Proceedings of the Prehistoric Society
PSAS	Proceedings of the Society of Antiquaries of Scotland
R	Right Side
RA	Rheumatoid Arthritis
RCAHMS	Royal Commission on Ancient and Historic Monuments (Scotland)
RN	Royal Navy
SC	'Side Chamber' prefix (in Isbister Chambered Cairn: SC*)
sd	Standard Deviation
SDD	Scottish Development Department
ST	'Stall' prefix (in Isbister Chambered Cairn: ST*)

TB	Tuberculosis
UBC	Unicameral Bone Cyst
Y	Yes
YA	Young Adult

1. INTRODUCTION

"Orkney is a magical Viking place with its own peculiar atmosphere that intrigues Billy. That's where he invented the bare-bum dance. He did it because he didn't know what to do with the standing stones. *'At the end of the day, they're just standing stones,'* he complained. *'You can eulogize all you like about astronomy and pre-Christian religions, but no one knows what the fuck they are.'* Billy strongly recommends that the notice boards in historical sites such as that do a rethink. Instead of guessing the purpose of the stones, he would prefer something rather more frank: *'We have no idea what this is. Try and leave it the way you found it.'* His own solution to addressing the mystery of the ancient stones was to resist stating the obvious and simply dance around them naked, like an old Celt."

Pamela Stephenson *Billy* (2002:346).

"It is much to be regretted that there is no national collection of the sepulchral remains of our ancestors. Ample resources yet exist for enriching such a collection, were it but commenced; but these resources are diminishing every day. Great numbers of skeletons have been found, and the bones scattered, within my knowledge, during the last few years …How much might the Society of Antiquaries have effected, if their attention had been directed to these researches!"

J.C. Prichard *Researches into the Physical History of Man* (1841 vol.III:xxi–xxii)

1.1 Rationale

This research aims to bring the dead to life. Despite extensive archaeological investigation, understanding of Neolithic Britain remains poor, partly due to historic failures to exploit information from human remains. I have attempted to redress this in a limited fashion, analysing skeletal collections from a heavily researched region with exceptional preservation. I then employed synthesis to address the question: “What was life like for people in Neolithic Orkney?”

Orkney has the best-preserved Neolithic remains in northern Europe and it might be expected that Neolithic Orcadian life should be well understood; this is not the case. Although archaeology is “the science which deduces a knowledge of past times from the study of their existing remains” (Chambers’ English Dictionary 1898), in practice it becomes “the systematic description or study of antiquities” (Oxford English Dictionary 1979). Artefacts and monuments are examined but the human element gets lost: people are rarely the focus of investigation (see Wysocki and Whittle 2000). The stated purpose of ‘The Megalith Builders of Western Europe’ (Daniel 1962, my emphasis) for example, was to “define what we mean by a megalith and by megalithic architecture” (Daniel 1962:128) - a more accurate title might have said ‘buildings.’ ‘The Megalith Builders’ (MacKie 1977) briefly described Neolithic people but relied on work already over 50 years old to do so (MacKie 1977:91-2). “If one evaluates the respective place of the diverse elements that make up a burial as a function of the number of written lines an author devotes to them in a publication, one often has the unfortunate impression that the deceased had been placed as an offering to a ceramic vessel or to a flint projectile point” (Duday 2006:30).

Early interpretations of prehistoric monumental sites, inspired by classical scholarship, related them to battle memorials and temples of the Romans or Britons and attributed barrows and standing stones to the 'Druids' (Stukeley 1740, 1743; Colt Hoare 1812:21; Thurnam 1869:163-4). Models related status of the deceased to monumentality and artefact assemblages, an approach still used in burial archaeology whilst acknowledging complications (e.g. Ucko 1969; Saxe 1970; Binford 1971; Kinnes 1975; Tainter 1978; Bloch 1981; Metcalf and Huntington 1991; Brown 1995). Scientific archaeology should "speak from facts not theory," (Colt Hoare 1812:7) but the facts employed sometimes seem selective and theories become paradigmatic: published studies on chambered tombs describe the monuments but give only cursory attention to human remains (see below). It has been suggested that Neolithic archaeology will particularly benefit from "… more detailed analysis of Neolithic burials," (Bradley and Gardiner 1984:3) but dating was envisaged rather than bioarchaeology.

"The anthropologist … must be aware of all the forces at his command …" (Penniman 1965:16-17). Archaeological investigation has recorded Neolithic waste, pottery, tools, settlements and ritual sites in great detail but seems divorced from real people. Human skeletal remains are direct evidence of the people themselves: providing data on age, sex, heredity and disease, exhibiting the scars of a lifetime's activities and reflecting intake of nutrients at an elemental level. "Surprisingly enough, however, little attention has been paid to the thousands of early British skeletons which have been excavated" (Brothwell 1960:318).

1.2. Aims and Objectives

"So far as the author can ascertain, the skeleton of British Prehistoric Man has not previously been dealt with in a systematic manner."

Cameron 1934:17

Aim

I aimed to discover what life was like for people in Neolithic Orkney by examining human skeletal remains. These are the most direct evidence available for people of the past and detailed osteological study should discover significant biological insights into the Neolithic human experience in Orkney. Several specific objectives and research questions were defined.

Objectives

The first objective was to macroscopically examine and accurately record the human skeletal remains from Isbister chambered tomb. This was intended to provide basic evidence underlying subsequent interpretation.

A second objective was comparison with other human remains from Orkney Museum's Neolithic collections and those at the Marischal Museum, Aberdeen, as well as published records. This was intended to address the possibility of intersite variation.

A third objective was stable light isotope analysis of human collagen (specifically $\delta^{13}C$ and $\delta^{15}N$). This was expected to provide data related to diet and metabolism that could be used to infer Neolithic lifeways. The question of whether the Isbister population would fit into existing subsistence models

(Clarke and Sharples 1990:81; Schulting 1998; Richards *et al*. 2003) was specifically tested because of environmental limitations on agriculture in Orkney compared with ready access to the sea and coastal resources; and contradictory evidence between settlement site remains and stable isotope analyses. A secondary element was a pilot study into fine age-resolution of isotopic changes through an innovative sampling method.

A fourth objective was radiocarbon dating of skeletal remains, to examine possible diachronic changes in variables previously identified.

The study was intended to examine pathology, congenital abnormalities, disease, nutrition, activity, sex and age at death. Interrelationships between the variables were examined to provide information regarding social roles: were there distinctions between the sexes or age groups; and what do such observations infer for Neolithic Orcadian culture?

Taphonomic evidence was examined in detail to place the remains in their depositional contexts and elucidate issues of burial practice and assemblage formation. It has long been recognised that chambered tombs cannot contain a significant proportion of their contemporary population from an extended period (Piggott 1954). Several deposition models could explain these numbers: a complete population over a short period; selection of high status individuals over a long period; or selection of the ‘unwanted’ dead over a long period (Barber 1988). It has recently been suggested that Neolithic tombs had interment use for a very short period (Whittle *et al*. 2007:129ff). This project sought to discover which model was likely and derive insights into Neolithic beliefs and practices.

The following section describes past investigations into Neolithic tombs, demonstrating historically limited use of human remains in synthesis. Orkney is nonetheless shown to be particularly significant for the study of the British Neolithic generally. This leads to the conclusion that osteological study of Orcadian human remains is a highly appropriate and yet underexploited method for informing any understanding of Neolithic life.

1.3. Historical Background: Archaeology and Neolithic Tombs

'Did these bones cost no more the breeding but to play at loggats with 'em?'

Hamlet, act V, scene 1

Early Origins and Investigations

Tombs are arguably the most common form of Neolithic monument (Daniel 1962:128). The mounds of Neolithic Britain have however been altered almost since they were first constructed. Neolithic rebuilding or elaboration, late Neolithic / early Bronze Age cuts and infilling of the monuments are frequently reported (Hedges 1983:22; Sharples 1985a:117-9). Later Bronze Age burials intrude (Renfrew *et al*. 1983:66; Lee 2011a) and Iron Age interest in these monuments led to incorporation into brochs and roundhouses (e.g. Sharples 1985a:119; Ballin Smith 1994; Renfrew 1979:181,186-8).

The earliest historical record of an Orcadian Neolithic tomb is the Orkneyinga Saga's description of Maes Howe. Earl Harald Maddadarson and his men crossed Orkney at Yuletide 1153:

> "*Þeir vóruí Orka-haugi, meðan él dró á*." (Vigfusson 1887:187)
> 'They were in Maeshowe while a snow storm drove over them.'
> (Taylor 1938:310)

The identification of Orkahaugi as Maes Howe is confirmed by 12th century Norse runes carved on its walls, which reads:

> *'Jórsalafarar brutu Orkhaug.'*
> 'Jerusalem-travellers broke Orkhaugr.' (Barnes 1994:189).

These inscriptions are evidence of 'tomb-breaking' but also demonstrate superimposition of later cultural features over early monuments. Further inscriptions in the tomb suggest one motive for early investigations:

> *'Þat var longu, er hér var fé folgit mikit.'*
>
> 'It was long ago that great treasure was hidden here.'
>
> (Barnes 1994:195).
>
> *'…ga er mér sagt at fé er hér folgit œrit vel.'*
>
> '…is told to me that treasure is hidden here well enough.'
>
> (Barnes 1994:93).
>
> *'Sæll er sá, er finna má Þann auð hinn mikla.'*
>
> 'Happy is he who can find the great wealth.' (Barnes 1994:196).

Grave robbing has been a major reason for excavating mounds, not only for valuables but also bones (e.g. Aubrey 1980:52, written *c*1654-95). Monuments might be quarried as a convenient source of stone (Piggott 1962:4, Marsden 1999:7). Mounds might be obstacles to be cleared or removed for display (Daniel 1960:219). Treatment of discovered bone was often casual: good preservation of human skeletal remains in one 'Druid Barrow' was noted, because "they would bear being thrown for a considerable distance without breaking," (Colt Hoare 1812:163). Bones might be spread on fields as fertiliser (Sabiston 1957). Tombs may suffer from weathering, vegetation growth, animal activity or plough damage but such incursions were rarely recorded historically (e.g. Whittle *et al.* 1999:79). These factors have led to the loss of much of the prehistoric funerary landscape (Thomas 1851:5; Petrie 1849 quoted in Davidson and Henshall 1989:15). As early as the eighteenth century, the work '*Nenia Britannica*' recorded that some barrows survived only in sparse manuscript accounts (Douglas 1793) and Aubrey had described attrition a century earlier (Aubrey 1980 - written 1654-95).

Nineteenth Century Antiquarianism and Questions of Race

Early investigators rarely retained the human remains that they encountered, neither did they often subject them to scientific study. In the late eighteenth century and through the nineteenth, interest in the human past increased and was related to anatomical considerations (Blumenbach 1775, 1795; Prichard 1813; Wells 1818; Lawrence 1819). Initially hampered by conservative opposition, and accusations of blasphemy, research was stimulated by the works of Darwin (1859, 1871), Prichard (1837–44), Lyell (1863) and Huxley (1863). An affluent educated middle class arose, notably doctors (e.g. Thurnam 1810-1873), landowners (e.g. Pitt Rivers 1827-1900, Colt Hoare 1759-1838) and clerics (e.g. Greenwell 1820-1918), with the leisure time to undertake more directed investigations, sometimes inspired by their professional interests. Much significant material appeared in the aptly named 'Gentleman's Magazine' from the early eighteenth century on (Gomme 1886). Scholarly debate led to the formation of learned societies and the launch of their journals (e.g. *Archaeologia* in 1770, *Archaeologia Scotica* in 1792 etc.). Papers in the *Memoirs of the Anthropological Society of London* reflect growing interest in evolution and racial affiliation, which led to publications such as ‘The Races of Britain’ (Beddoe 1885) and ‘The Races of Europe’ (Ripley 1900).

In the nineteenth century, craniology, especially for investigating ‘race’ (Blumenbach 1775, 1795; Prichard 1813; 1837-44, 1841; Lawrence 1819), stimulated archaeological collection of skulls. The crania collected and described were not necessarily representative: there was a tendency to prefer good examples of perceived cranial types and juvenile crania and other bones might be ignored (e.g. Childe 1954:122-3). The applications of skeletal studies to investigating human development were to lead to important theoretical advances. The work of Karl Pearson (1857-1936) and colleagues profoundly influenced modern statistics. The journal *Biometrika* carried significant anthropological discussion (see Galton 1901), and particularly a section of 'craniological notes'. In some respects, development of statistics is one of the most important advances for archaeology (Daniel 1975:372). Racial affiliation has proven less useful (Howells 1995:103).

Medically trained observers sometimes produced work of a high standard, including significant compendia of crania (e.g. Davis and Thurnam 1865; Morton 1839, 1844). Thurnam notably published a series of papers describing crania, with age and sex attributions and features such as rugosity or parietals "studded with fine perforations" (Thurnam 1865a:259). He defined the 'long barrows = long skulls; round barrows = round skulls' hypothesis (Thurnam 1865b, 1869). Racial affiliation was addressed by comparisons with groups of crania in anthropological collections. Cases of premature craniosynostosis and occasional subsequent dysplasia in some individuals were noted but Thurnam considered that this was not necessarily the cause of dolichocephaly in long barrow crania (Thurnam 1865a). Concavity of crania superiorly was described and its aetiology discussed (Thurnam 1865a:261-2). Thurnam's work exhibits awareness of taphonomic deformation and problems of provenance (e.g. Thurnam 1869:45); he recognised "cleft skulls" as evidence of violence, noted the presence of red deer and cattle bones in tombs; and distinguished primary from later interments. He attempted to explain fused cervical vertebrae through activity – albeit as trauma due to low headroom in living spaces. But for the limited chronology and undue influence from classical authors, his accounts of skeletal remains from Neolithic tombs are close to many modern observations: many features have been independently described from other sites.

The quality of excavation, recording and reporting among antiquarians varied greatly. Lysons' extensive work primarily attempted an etymology of monument names (largely spurious, from Hebrew and classical texts) but also drew on Thurnam's work and the excavation of Windmill Tump, Rodmarton (Lysons 1865, especially p137ff). Lieutenant Thomas RN, described the antiquities of Stenness, Orkney, with excellent survey work that was not to be equalled until the late twentieth century (Thomas 1851; Ritchie 1976). James Farrer MP, also working in Orkney in the mid nineteenth century, was probably more typical. Farrer was an enthusiastic excavator but rarely published results. His excavation reports are essentially just brief notes accompanying finds sent to museum collections (Farrer 1857a, 1857b, 1857c, 1868a, 1868b & 1889; Stuart 1857). His monograph on Maes Howe has more content but the detail was mostly supplied by Thomas, Petrie and the translators of the runic inscriptions (Farrer 1862). Few of Farrer's finds were subjected to analysis: following his excavation of Quoyness chambered tomb, "the skulls were sent to Thurnam in London, but the remaining bones were unceremoniously dumped back where they had been found," (Childe 1954:121-3).

The Orcadian antiquarian George Petrie published the results from numerous of his own and others' excavations over many years, including the discovery of Skara Brae (e.g. Petrie 1857, 1860, 1866, 1867, 1870, 1888). He was acutely aware of the loss of archaeological remains and said of mounds in the parish of Sandwick: "a few years ago about a hundred of these were to be seen…but these interesting memorials of the past are fast disappearing before the agricultural improvements of the present age which appropriate and swallow up the materials of which these old sepulchral monuments are constructed, and what is more provoking still without any attention being given to preserve a record of their construction and contents" (Petrie 1849, quoted by Davidson & Henshall 1989:15).

In 1884, Unstan Neolithic chambered tomb was excavated, becoming the type-site for a form of round-bottomed pottery. Descriptions and illustrations of the pottery and a number of stone implements were published (Clouston 1885). There was evidence of several human inhumations – at least two being flexed - and the bones were "submitted to Dr. J. G. Garson, Royal College of Surgeons of England," but there is no record of their examination (see Garson 1884:54-5) and few known bones survive in the NMS collections (Davidson and Henshall 1989:167).

Canon William Greenwell, working in the north of England around this time, produced an extensive account of his excavations of numerous barrows, to which was appended a detailed exposition on a selection of 13 skulls (Greenwell 1877; Rolleston 1877). Oxford anatomy professor, George Rolleston devoted many pages to the affinities of these skulls and recorded a number of abnormalities, noting Thurnam's suggestion (p11 above) that some features occurred because "heads and necks … would have been very much exposed to violent concussions against the sides and roof of their narrow passages and doorways." Cases of periodontal disease were described (Rolleston 1877:701ff) and features were attributed to diet, environment and activity (Rolleston 1877:661,705). The emphasis though was on racial comparisons and relating 'savage races' to the supposed tribes of stone-age Britain. Rolleston's cranial illustrations and skeletal descriptions are sometimes sufficiently detailed to be useful. The Rudston cranium (Rolleston 1877:612-5) exhibits what may be a depressed fracture of the left parietal (unremarked in the text) and alveolar abscesses. The Helperthorpe cranium is visibly asymmetric, which was remarked upon and attributed to "mode of carriage in infancy" but apparent orbital asymmetry went undescribed (Rolleston 1877:616-8). This illustration also appears to show an unmentioned depressed fracture to the right parietal, with anterior radiating fractures. In the absence of sufficiently detailed description, illustrations defy proper diagnosis but offer tantalising suggestions that more remained to be learned from the bones.

James Mortimer excavated (mostly Bronze Age) barrows in East Yorkshire. His voluminous notes (Mortimer 1905) make only cursory mention of human remains: "an ordinary archaeologist probably considers the collecting of other relics more important than securing the bones, for these are … comparatively useless," (Mortimer 1905:41). Although plans show skeletons, the text typically only describes form of deposition, with some long-bone measurements. Only from Duggleby Howe were skulls and longbones described in more detail (a mere selection) (Mortimer 1905:23-42); emphasis was on type and osteometry and incorporated Garson's first-hand descriptions of the crania but failed to note several important details identified since (Ogden 2009).

Borlase’s investigations in Cornwall were compiled with earlier accounts (Borlase 1872), which produced idiosyncratic results. The only specific skeletal detail was the comment that a lumbar vertebra measured 2” transversely by 1 1/10” thickness (Borlase 1872:86). No osteologically significant information was given, although poor local preservation may have been a factor.

A thorough treatment of prehistoric Irish tombs appeared at the end of the nineteenth century (Borlase 1897). It covered architecture, distribution, folklore and comparative physical anthropology. This was very much of its time in accepting vague similarities between monuments, names and words in different languages as evidence for relationships (e.g. Borlase 1897:1158ff; as with Lysons 1865, p11 above). Osteology inevitably concentrated on craniometry to adduce racial affinity from type but relied heavily on previously published examples (Borlase 1897:917ff).

At the beginning of the 20th century, the barrow excavator anatomy professor T.H. Bryce MD described his discoveries in considerable detail over several long papers, including structures and human remains. He maintained a particular interest in craniometry whilst discussing the whole skeleton but considered mixed remains to have less value (Bryce 1927:302). Emphasis remained on measurement and racial identification (e.g. Bryce 1902:138-162).

The 1902 *PSAS* also held a paper describing Cuween Cairn in Orkney (Charleson 1902:733-8). The complete excavation of the tomb was summarised over eight pages: two given to a skeletal report, most of which was craniometric. The remains “were so very imperfect” that little was determined except that of 5 crania studied, all individuals died old, two were probably males and one was dolichocephalic (Charleson 1902:736-8). Recent examination has identified additional perimortem blunt force trauma (Rebecca Crozier pers. comm.).

In 1904, a ‘*Notice of some Ancient Burials in Orkney’* was published, in which a dolichocephalic cranium was briefly described and compared to another from the same site (Charleson 1904). Site location was not given: and such lack of provenance is another recurrent problem for us today.

<u>Early Twentieth Century Consolidation</u>

in 1920, OGS Crawford was appointed archaeological officer of the Ordnance Survey. His talents were particularly expressed in use of aerial survey (which notably led to identification of Woodhenge), his study of Cotswold Long barrows and as the founding editor of *Antiquity* (Crawford 1925; Crawford 1928 etc). His synthesis of Cotswold long barrows leant heavily on existing reports, notably the osteological observations of Thurnam, but included acute first-hand observation and detailed survey work. A small number of cranial lesions were noted that had apparently (and inexplicably) been missed previously (Crawford 1925:75; Thurnam 1865a). The volume also included an essay on folklore associated with Neolithic monuments, perhaps presaging his later work on goddess symbolism (Crawford 1957): another theoretical theme that developed through the twentieth century.

'*The Antiquity of Man*' (Keith 1915, 1929, 1931) is the apotheosis of this period of investigation, synthesising cranial studies to elucidate human evolution. His first chapter was based on a study of human remains from the Coldrum megalithic tomb. Significant observations were made, many of which have been reported independently from other Neolithic assemblages. "Three of the nine skulls had anomalous bones set within the joinings or sutures of the vault; some of the others showed irregularities in the manner in which the sutures between the skull bones became closed" (Keith 1929:8). Stature was calculated based on femoral length and found to average 5'4.5" for males, 5'1" for females (Keith 1929:8-9); the crania were dolichocephalic (Keith 1929:9ff); teeth were worn but not carious and yet there were "abscesses or gumboils at the roots" (Keith 1929:13); the femora and tibiae displayed platymeria and platycnemia (Keith 1929:13). Keith's discussion attempted to link skeletal observations with causative behaviour and diet. His Figure 4 depicts a cranium with an anomalous bone at bregma and close examination suggests that the orbits and the nasal orifice are markedly asymmetric – the left side is smaller and, in the case of the orbit, possibly so much so as to have had clinical consequences. Little of this was described in the text. The book was limited in its aims: crania were attributed to 'types' and the postcranial skeleton received little attention. Keith's Coldrum data were the most recent of the seven Neolithic series included in a later review of British cranial forms, which was otherwise largely based on mid nineteenth century material (Morant 1926).

The 1930s saw a series of important publications of human skeletal studies. '*The Skeleton of British Neolithic Man*' summarised observations regarding almost the entire human skeleton (Cameron 1934). This was based largely on the bones from Coldrum megalithic tomb, which were put into context by comparison with bones from other periods and from the Mediterranean region. Sound anatomical knowledge was combined with osteological experience and the use of statistics. Assumptions were clearly defined. Pathology, stature and activity were all discussed but emphasis remained on interpopulation comparisons and summary statistics rather than investigation of variation. The author noted that in his experience of prehistoric bone, there was little evidence of disease: only a single type of trauma (fractured clavicles, all healed), two examples of trepanation, dental or periodontal disorders and osteoarthritis (hip, knee, shoulder, vertebrae and TMJ) (Cameron 1934:234-5). Particularly depressing is the final chapter, in which the holdings in British museums of ancient British human skeletal material are enumerated. This demonstrates both a paucity of remains from excavations and a general lack of provenance information (Cameron 1934:257-64).

Windmill Hill causewayed enclosure was described in the eighteenth century by Stukeley (Long 1858; Whittle *et al.* 1999:1) but its mounds were soon to be largely ploughed out (Colt Hoare 1821:95-6, see also pp85ff). Excavations in the late 1920s recovered both articulated skeletons and fragmented bone (human and animal) from the ditches. The famous pottery was quickly reported

(Piggott 1931). Excavation results were published much later (Smith 1959, 1965), including a five-page catalogue of skeletal data (Brothwell in Smith 1965:136-140). Major osteological information did not appear until 1999 (Brothwell in Whittle *et al*. 1999).

Excavation and reporting of a previously undamaged side cell at the Lanhill long cairn represented the state of the art for 1930s archaeology (Keiller and Piggott 1938). Layers were photographed and find locations recorded in detail. The publication had a detailed appendix that organised the scattered bones into probable skeletons, which were described to give biological profiles (Cave in Keiller and Piggott 1938:131-50). Emphasis remained on osteometry of complete bones and attempted diagnosis of racial type, even suggestions of hair and eye colour and facial reconstruction. Major pathological and congenital features were described, including post bregmatic concavity, Wormian bones, supernumerary and impacted teeth, severe periodontal disease, ante mortem tooth loss and one highly dysplastic elbow joint. The accuracy of this osteological work has recently been confirmed (Smith and Brickley 2009) but the results were barely mentioned in the main text. The same is true of the paper that followed it in the volume, describing the chambered tomb excavation at Nympsfield (Clifford 1938). Again the skeletal report (Fawcett in Clifford 1938:211-2) was an appendix and fragmentation of the assemblage had a detrimental impact; what appears is effectively a simple list of bones.

1930s Orkney

The 1930s were particularly significant for archaeological investigation in

Orkney. Earlier in the twentieth century, a number of sites had been taken into Guardianship by the Commissioners of H.M. Works Department. New excavations took place in preparation for conservation and to ready monuments for display. The best known of these was Skara Brae, under threat from coastal erosion (Childe 1930, 1931a, 1931b, 1931c; Childe & Paterson 1929). Other Works Department projects typically involved clearing and conservation for public display with little or no formal recording beyond the foreman's notebooks. Occasionally reconstruction could be inappropriate (e.g. Ritchie 1976:17-8; Ritchie 2004). Emphasis on site presentation created a culture in which complete excavation is rare and we have little knowledge of what lies beneath, within or outside most monuments. This has the effect of implicitly emphasising architecture as having particular significance to Neolithic archaeology.

On the island of Rousay, Walter Grant undertook a number of excavations of megalithic tombs in partnership with J.G. Callander, NMAS Director. Results were initially published to a high quality, with detailed skeletal reports by A. Low, Professor of Anatomy at Aberdeen (Callander and Grant 1934a, 1934b, 1935, 1936, 1937). Midhowe was particularly significant, with its great size and decorative use of stone. The records dealt methodically with skeletal deposits and described flexed inhumation on stone flag ‘benches’ between orthostats forming stalls (Callander and Grant 1934b:330-5). Low described three mostly complete crania and noted dolichocephaly and dental attrition, commenting that there was dental crowding, irregularity and impaction; there were indications of alveolar infection but no caries (Low 1934:344); each cranium exhibited TMJ osteoarthritis (Low 1934:343-8). Complete long-bones were described and exhibited platymeria, platycnemia and superior tibial retroversion. Not mentioned were the possible cuts and depressed fractures apparent on the photographs of skull 12 (Callander and Grant 1934b:figs. 22 and 25). These remains (including complete skeletons) have been lost (Henshall and Davidson 1989:148).

The Knowe of Yarso report followed the same methodical form and described discovery of crania at the bases of walls (Callander and Grant 1935). Parts of 36 red deer were discovered, and numerous limpet shells, although the tomb is high on a hillside (Callander and Grant 1935:334). It was suggested that the chambers had been used as laying out places and that the skeletons were reorganised after the flesh had been lost (Callander and Grant 1935:339). Skeletal analysis of the 29 individuals was explicitly limited to mostly complete bones and ignored the fragmented majority. One description was of a markedly plagiocephalic cranium, with CI of 63.3 (Low 1935: figs. 16-19). This cranium is the only bone from the site whose whereabouts are known today (at the Marischal Museum, Aberdeen).

After Callander's death in 1937, Grant continued excavation but failed to publish consistently: four of the nine Neolithic chambered cairns he excavated have no report, although plans and notes survive in the NMRS. The human remains were stored in museums, where some (Knowe of Rowiegar's) were recently rediscovered (Card 2005a:43; Davidson & Henshall 1989:6-7; Meg Hutchison pers. comm.). Blackhammer, with decorative use of stone walling, was described as having two skeletons in the basal layers but their description is a mere list of fragments in two paragraphs (Callander and Grant 1937).

Grant's description of 'Taiverso Tuick' followed re-excavation by MoW in 1937. It noted later cists, blocking of the entrance passage, the two-storey structure and an adjacent 'miniature chamber' (Grant 1939). On this occasion, Grant did not commission any specialist reports but described the finds and bone fragments himself. Only a single mandible fragment was identified as human, other remains having been removed in 1898 (Turner 1903). A feature that seemed anomalous was a stone roofed 'drain' 2-9" deep beneath the lower entrance, containing pottery vessels. Grant believed that this could not have been a functioning drain and its purpose remains obscure but a similar feature has since been recorded at Maes Howe (Richards 2005:237-242) and there is some resonance with observations regarding cave burial and 'abnormal water' at Scaloria in central Italy (Whitehouse 1992).

The Knowe of Lairo was partly excavated in 1936 (Grant and Wilson 1943). The site exhibited unusual architectural features – chambers above the floor level, high corbelled vault, internal walling, a long horned mound. Although there was a brief discussion of finds, human bones mentioned in the text went undescribed (Childe in Grant and Wilson 1943). Few are known today (at the Marischal Museum, Aberdeen).

1936 saw the excavation of a cairn on Calf of Eday, which proved to contain two chambered tombs: a stalled cairn respecting and possibly replacing an earlier smaller simpler monument (Calder 1937). The stalls appear to have held ‘benches’ in a similar form to Midhowe (Calder 1937:121). The larger chamber contained human remains and the skeleton of an otter, whilst the entrance passage to the smaller had been intentionally filled. The cairn had been reused in the Iron Age, possibly as a pottery kiln. Pottery and animal bones reports were detailed (Callander in Calder 1937:134-151, Platt in Calder 1937:152-154) but the human skeletal report is merely a six line list of fragments with no further comment (Low in Calder 1937:151). Calder later investigated a two-storey tomb at Huntersquoy on Eday, a stalled cairn at Sandyhill Smithy on Eday and a tripartite (possibly 4 or 5 stalls) tomb on Calf of Eday. No human bone was described from the site but possibly none survived (Calder 1938).

Post-War Uncertainty and Synthesis

Biological anthropology became unfashionable in the late 1930s through to the 1950s (Penniman 1965:300). This is graphically illustrated by *Biometrika* (Cox 2001:8-9, Davison 2001:13): until 1945 virtually every issue contained one or more osteological papers but only one such paper appeared following the Second World War (Batrawi and Morant 1947). Osteometry survived in explicitly anthropological journals but was increasingly supplanted by biochemical studies (Brothwell 1968:12, Caspari 2010). Intergenerational plasticity of the cranium had been recognised as early as the beginning of the 20th century (Boas 1911:5) and uncertainty regarding previously held views of racial stereotypes served to undermine confidence in anthropometry (e.g. Weiner 1964:230-1; Kenna 1964; Caspari 2010:116). A series of well-written osteometric treatises maintained the discipline (e.g. Fereday 1956; Brothwell 1963; Howells 1973; 1989; 1995) but geographic, environmental and culturally determined variation were increasingly identified (e.g. Weiner 1964; Caspari 2010).

'*The Ancient Burial Mounds of England'* (Grinsell 1953) devoted 253 pages to its subject. Human remains however were barely mentioned except that "Provision of the dead with retainers, slaughtered for the occasion, is clearly attested in some instances, where skeletons with cleft skulls or other mortal wounds have been found immediately above presumed primary burials showing no signs of injury," and that there had been "the frequent placing of the body in the crouched position" (Grinsell 1953:33), plus two short paragraphs describing forms of cremation. Treatment had arguably been better in the first edition, where "people were often buried in the contracted position," and "Frequently the custom was to expose deceased in an ossuary in the open air for several weeks or months before burial, and then to place a selection of his bones in the long barrow erected in his honour," (Grinsell 1936:34). Grinsell's discussions of typology, distribution and symbolism would not be out of place in more modern treatments but his failure to describe or interpret human remains (despite being listed, where available, in his regional studies, e.g. Grinsell 1959; O'Neil and Grinsell 1961) indicates a general lack of suitable published skeletal data and failure to recognise their significance.

Earlier medical descriptions and appendices might almost not have existed.

Glyn Daniel synthesised understanding of the "chamber tombs" of England and Wales (Daniel 1950). In 250 pages of text, 17 discussed human remains – entirely in the context of tomb use ritual (Daniel 1950:98-115). Pottery, bone and stone artefacts were described as “a dismal catalogue” that “illustrates forcibly the paucity and lack of variety of the finds from our burial chambers,” but nonetheless received 24 pages, describing types and find locations (Daniel 1950:122-145). Daniel cited earlier skeletal observations but only to say that the people of the tombs were ‘longheads’ with longbone flattening and slightly shorter than the modern average (Daniel 1950:174-5). Ten years later, addressing French tombs, Daniel again glossed over the human remains, stating merely numbers of skeletons found (Daniel 1960:127,215) or that skulls were of the long- or round-headed type (Daniel 1960:127), although trepanation was mentioned (Daniel 1960:46). Architectural detail and artefact study were the major themes (Daniel 1960:191ff). Daniel’s main purpose was “to make a general survey of the megalithic tombs,” their variety, grave-goods and distribution, possibly reflecting their availability (Daniel 1960:212; see p19 above). In his paper on the Neolithic in a volume entitled ‘*The Prehistoric* *<u>Peoples</u>* *of Scotland’* (Piggott 1962b, my emphasis), there is no actual discussion of people (Daniel 1962b). Daniel noted that “detailed knowledge of the way of life and the material culture of the megalith builders must… be drawn from the tombs” - and proceeded to discuss pottery (Daniel 1962b:56).

Archaeological method was increasingly addressed in textbooks. Human bones “should be preserved for examination by a physical anthropologist,” who might determine age, sex, height and ethnic group, possibly evidence of disease, wounds and fractures (Atkinson 1953:75). Although the significance of such observations was not discussed, Atkinson proposed that the skull, limb bones and pelvis should especially be collected (Atkinson 1953:75). Osteology did not appear in Atkinson’s chapter on interpretation, despite recognition that the archaeologist’s purpose is study of the human community (Atkinson 1953:160ff). It was noted that the use of specialist appendices (including human remains) relieved the main text of “tedious catalogues,” whilst making detail accessible (Atkinson 1953:176-7). Wheeler stated that the aim in excavating burial deposits was to “reconstruct the ritual represented by the particles of evidence” (Wheeler 1954:113). Pointing out that the usual specialist bone report “gets us almost nowhere,” he launched a plea for improved qualitative and quantitative analyses that might facilitate interpretation – but only in the context of <u>animal</u> bones (Wheeler 1954:191-2).

In keeping with this ethos, Piggott’s ‘*Neolithic Cultures of the British Isles*’ were essentially material cultures of architectural and artefact types and distributions (Piggott 1954). He discussed burial form, describing disarticulated and fragmentary remains as evidence of cannibalism (Piggott 1954:47-8). Evidence of single and multiple inhumations and cremation was discussed and summary tables indicated numbers of adults, children, males and females (Piggott 1954:60, 140, 165, 247). These features were employed almost entirely to indicate use of the tomb and not as any kind of investigation into the people. In over 400 pages, physical anthropology was confined to a single paragraph where he mentioned “the physical anthropology of the Neolithic colonists, <u>though only to dismiss it</u>” (his words, my emphasis), merely quoting the by now familiar dolicocephalic skull shape and a supposedly typical gracile Neolithic skeletal form (Piggott 1954:368).

In his '*Approach to Archaeology*,' Piggott noted the importance of archaeobotany, zooarchaeology and artefactual evidence (Piggott 1959:49ff). The significance of burial sites though was "to be placed in a category" (Piggott 1959:58-9). Artefact and monument typologies were emphasised (Piggott 1959:100; as seen above), whilst megalithic tombs might provide evidence of ritual (Piggott 1959:107ff). Piggott commissioned osteological reports, although they were not always published (e.g. Piggott 1956:198). The best-known and probably best-preserved tomb that he excavated was West Kennet (Piggott 1958; Piggott 1962). Piggott summarised from a specialist report on the human bones to assess numbers of individuals interred (MNI=32), noted the presence of gracile and robust types and claimed that the crania were consistent with a "North European strain in the British Neolithic population" (Piggott 1962:238). This is essentially all that appeared in the main text. Despite the presence of 19 text pages and several plates of osteological appendices (Piggott 1962:24ff, Wells 1962, Brothwell 1962, Lisowski 1962), little significance to archaeology was recognised in human bones beyond stature and affinity.

The publications of West Kennet and Fussell's Lodge Long Barrow (Piggott 1962; Ashbee 1966) nonetheless included arguably the earliest major osteological treatments from British Neolithic sites. The skeletal report in each case comprised 20% of the total pages with several plates (Piggott 1962; Brothwell and Blake 1966). Ashbee's own synthesis of long barrows (Ashbee 1970) perhaps exhibits somewhat deeper interests in human bones than earlier authors had but his "Burials" chapter and the associated appendix (Ashbee 1970:55-70, 135-153) betray interest in post mortem body treatment rather than biological inference. Although attempts were made to discern tradition, belief and social relationships, these were based on architecture, artefacts and apparent features of burial practice (with bone distribution and condition).

The first report on Isbister chambered tomb appeared in 1961 (Ritchie 1961). It included descriptions of the artefacts and a discussion of typological affiliations. The human skeletal assemblage was acknowledged as “the most complete yet to be found in a neolithic context in Scotland,” (Ritchie 1961:32), with at least 30 individuals ranging from very young to middle age. A full skeletal report was not considered possible and none was then published (Ritchie 1961:31).

Into the Late Twentieth Century

Readable, logically presented, concise and relatively complete textbooks of human osteological analysis suitable for archaeologists were published in the early 1960s (Krogman 1962; Brothwell 1963), soon followed by a more popular volume (Wells 1964). These works were available to a new generation of archaeologists being university trained. Inspired by interdisciplinary theoretical advances, techniques were developed for the recovery and analysis of a wide variety of different artefacts and ecofacts, dating and distribution. Archaeological emphasis though was well established and could still be described as “contemplating the relics [i.e. artefacts] … comparing them with similar relics found in different places” (Douglas 1793:v).

Failure to properly incorporate specialist reports in archaeological discussion continued, partly because of increasing workloads and emphasis on reporting new results. Whilst older assemblages languished in stores, rescue excavation and commercial archaeology led to an increase in rapidly undertaken, often under-resourced, projects. Human remains might be viewed as more of a time-consuming problem to be got rid of than an asset to investigation, leading to the joke that “If you remove human skeletons fast enough, they look like animal bones and can be thrown away” (Rahtz 1978:127). There were exceptions to this generalisation, notably Don Brothwell, who synthesised the Neolithic human remains from Britain, in a manner long associated with artefact studies: the resulting paper however (Brothwell 1973), in a German volume, continued to emphasise metrical approaches and evolution.

Despite the large number of excavations on Neolithic mortuary sites then, most reports and syntheses have concentrated on discussions of distribution, architecture and classification (e.g. Henshall 1963, 1972; Daniel 1950, 1960; Grinsell 1936; De Valera and Ó Nualláin 1961, 1964, 1972, 1982; Ó Nualláin 1989, Cody 2002; Herity 1974). In the culture historical approach, such classification of monument types all too often became an end in itself and once a monument had been duly classified and dots placed on the relevant maps, the archaeologist’s interest in it was finished (e.g. Piggott 1959:100; p26 above).

Attempts have been made to synthesise from these sites to infer burial rite and social structure (e.g. Darvill 1982; Whittle 1996:239ff, 2003:34-5; Woodward 2000; Darvill 2004:132-172; Field 2006). Of these works, Darvill's 2004 volume is a rare example that also synthesises from skeletal data to examine the Neolithic population but there has been an increasing trend towards overtly theoretical or phenomenological discussions of depositional meaning (e.g. papers in Cummings and Fowler 2004; Hofmann and Whittle 2008; Cummings 2009). Burial archaeology has sometimes been led by particular ethnographic case studies (perhaps most notably analogies between megalithic tombs and practices of the Merina and other groups in Madagascar (Bloch 1971; Parker Pearson 1992, 1999)) but wide variation and complexity of these factors is also increasingly recognised (e.g. Ucko 1969; Metcalf and Huntington 1991; Whittle 1998; Parker Pearson and Ramilisonina 1998b) and demonstrates the difficulties of transposition across cultures.

Towards Bioarchaeology

In the last few decades there has been a burgeoning osteoarchaeological literature, improved international communication and particular concern over standards. Important volumes have appeared on osteological technique and interpretation, stimulated by repatriation laws, forensic requirements and influential conferences (Brothwell 1968; Chapman *et al.* 1981; Boddington *et al.* 1987; Ortner and Aufderheide 1988; White *et al*. 2012; Krogman and İşcan 1986; Ubelaker 1999; Cox and Mays 2000; Katzenberg and Saunders 2000; Bass 2005; Mays 2010; Lyman 1994; Haglund and Sorg 1997; Haglund and Sorg 2002; Galloway 1999; Kimmerle and Baraybar 2008; Larsen 1997; Jurmain 1999; Ortner 2003; Roberts and Manchester 2005 etc.). Human remains have been studied with greater consistency, using defined methods (e.g. Ferembach *et al*. 1980; Buikstra and Ubelaker 1994; Brickley and McKinley 2004). New techniques, such as stable isotope analysis, have been developed, which are being applied to museum collections as well as to new discoveries and demonstrate significance to broader Neolithic issues.

Taphonomic influences are increasingly recognised (Barber 1997:68ff; Lawrence 2006b) so that patterns of deposition of human remains can be interpreted with greater accuracy, refining information on funerary behaviour (Boddington 1987; Roksandic 2002; Duday 2006; Duday 2009). Craniological affiliation is being increasingly superseded by biomolecular techniques (e.g. Cavalli-Sforza 2001; Sykes 2006; Oppenheimer 2007; Moffat and Wilson 2011). Such analyses can be difficult to apply retrospectively, especially for older excavations, because of the all too frequent absence of detailed records, loss of bones and contamination.

Opportunities to apply modern standards of analysis to large samples of Neolithic human remains in the British Isles have been rare. Many of the more prominent monuments were excavated early and their contents lost or poorly recorded (see Whittle and Wysocki 1998:150). In the last 50 years, the only new excavations on Neolithic sites to retrieve substantial quantities of human bones were Ascott under Wychwood, Hambledon Hill, Hazleton North, Quanterness, and Isbister (Chesterman 1977, 1979, 1983; Saville 1990; Mercer and Healy 2009); Banks may also become highly productive (see section 2.3 below). Other modern excavations have taken place but encountered fewer or poorly preserved remains, such as Crantit (Smith 2001), Giant's Graves Skendleby (Evans and Simpson 1991), Point of Cott (Barber 1997) or Haddenham (Evans and Hodder 2006). Discussion of Neolithic life is becoming more sophisticated. It remains rare however for syntheses to escape the preconceptions of the past, a problem compounded by the long history of poor excavation and reporting. The burgeoning body of specialist literature is perhaps obscure for archaeologists discussing settlements or subsistence, though stable isotope results are increasingly recognised as having broad significance.

Some modern reports present difficulties. Of the largest modern assemblages, J.T. Chesterman examined three (two from Orkney); each of these has been reassessed and the original reports shown to have led to erroneous interpretations (Lawrence 2006, 2006b; Benson 2007:22; Galer 2007:189; Rebecca Crozier pers. comm.). The report on the human remains from Point of Cott (Lee 1997) lacks some important details and contains typographic and other errors, also disagreeing with comparable parts of Lee's thesis (Lee 1985) and making interpretation difficult.

When compiled for a specialist volume on 'Health and Disease in Britain', Neolithic data was found to be particularly limited and uneven (Roberts and Cox 2003:26ff). Without standardised reporting, there can be no adequate study of regionality or other variation. An apparent absence of evidence for Neolithic pathology seems unlikely to reflect prevalence in populations that would have been chronically exposed to pathogens and trauma (Roberts and Cox 2003:58ff). The 'osteological paradox' may present one explanation but inaccuracies and underreporting of detail in early analyses of Neolithic bone are probably major factors (Wood *et al*. 1992; Smith 2005; Lawrence 2006a).

Ideas that the Neolithic was a time of health, peace and plenty, possibly owing their popularity to idealism, have been repeatedly and conclusively demolished (Cohen and Armelagos 1984; Cohen 1989; Mercer 1999; Moore 2004; Schulting and Wysocki 2005). Interpersonal violence in the British Neolithic is now widely recognised, based on recent osteological reports; possibly even warfare (Schulting and Wysocki 2005; Smith and Brickley 2009; Schulting 2012; Mercer 1980:65; Mercer 1981:188; Mercer 1988, 1999; Dixon 1988:82). Artefactual evidence for this was uncertain: numerous arrowheads could indicate hunting (Case 1969); axes and bone points may have been tools; many stone items, including maceheads, carved balls and pointed objects have been preferentially interpreted as having some ritual function (Clarke *et al*. 1985:45ff). Bone damage provides unequivocal proof (e.g. Corcoran 1967; Schulting 2012).

If older osteological reports are commonly incomplete, inconsistent or erroneous (Roberts and Cox 2003; Lawrence 2006; McKinley 2009), then there is inevitably an historic reliance on "…impressionistic anecdotes, supported by a handful of poorly excavated and published sites…" and "surprisingly few collections have been studied for palaeopathological data" (Beckett and Robb 2006:58). The Neolithic palaeopathology data quoted by Roberts and Cox came by default almost entirely from the work of just 2 analysts on assemblages from 2 sites (Roberts and Cox 2003). Further new or revised reports have been published since, on Haddenham (Evans and Hodder 2006; Lee 2006; Dodwell 2006), Hambledon Hill (McKinley 2009), Holm of Papa Westray North (HPWN) (Harman and Lee in Ritchie 2009) and Ascott-under-Wychwood (Galer 2007). Excepting Hambledon Hill, none has a particularly large or well-preserved skeletal assemblage but the Hambledon Hill assemblage was not compiled as a full osteological report (McKinley 2009:477). This is a poor sample to represent the whole of Neolithic Britain.

The skeletal evidence for health status in the British Neolithic is dominated by the published report from a single site: Isbister chambered cairn, Orkney, from which few lesions were identified (Hedges 1983). Chesterman's specialist report purports to describe a minimum of 340 individuals. This alone is a nominal 44% of the 772 Neolithic individuals available for synthesis of archaeological evidence for health and disease in Britain (Roberts and Cox 2003 – in total, 498 of the individuals cited had descriptions published by Chesterman: 65%!). Such a large assemblage might be expected to provide reliable information regarding Neolithic life but the report has been shown to have systematically misinterpreted pathological lesions as taphonomy, attributed age at death with undue precision and inflated numbers of individuals (Lawrence 2006b).

Misinterpretation of published studies is also rife. It has, for example, been stated that at Isbister "all the skulls were gathered together into one small chamber" (Lynch 2004:15) and that "Different body parts, like skulls and long bones, had at some stage been collected into separate groups" (Ashmore 1996:48) but both claims are overstated at best and claim specific actions. It is often suggested that certain bones are missing from assemblages in a structured way with implications for past beliefs and behaviour (e.g. Shanks and Tilley 1982; Richards 1988; Thomas 1988; Fowler 2010:1 and 17) but supporting data is usually presented in an inferential manner that is rarely tested with statistical robustness and explanations may be related to taphonomy and recovery factors (Waldron 1987; Cox and Bell 1999). Suggestions of circulation of human bones in the Neolithic were interesting studies in speculation (Gresham 1972; Richards 1988:50) but are difficult (arguably impossible) to demonstrate or disprove because we lack evidence for the nature of bone movement and loss (*contra* Jones 2008:195-6; Reilly 2003; Baxter 1999; Fowler 2010).

In recent years, there has been a tendency to revisit the older skeletal assemblages. This has permitted the application of modern standards and newly developed techniques to their analysis and has proven highly fruitful (Whittle and Wysocki 1998; Smith and Brickley 2009; Schulting and Wysocki 2005). Publication of conference proceedings (e.g. Parker Pearson and Thorpe 2005; Schulting and Fibiger 2012), thematic volumes (Smith and Brickley 2009) and site monographs (e.g. Saville 1990; Mercer and Healy 2009; Barber 1997; Ritchie 2009) have finally begun to address the lack of detailed osteological data and informed interdisciplinary discussion. Much more is needed.

Osteological data has rarely been fully exploited in archaeological syntheses. Whittle has taken human skeletal data to illustrate his work (Whittle 2003:7ff) but notes the general failure to integrate such information into studies (Whittle 2003:25). Whittle's assertion that it is only recently that such studies have been applied demonstrates how little influence comments in earlier work described above (pp11ff) have had. Refreshingly, Whittle acknowledges and discusses MSM, anthropology, palaeopathology and '*l'archaeologie du terraine*' (Whittle 2003:29ff and 157): for once we do get 'The Archaeology of People." In contrast, one recent review of ‘Prehistoric Britain,’ included a section on ‘Farmers and their Landscape’ but largely omitted the farmers except as objects to be deposited, giving osteology a cursory single paragraph in contrast to an earlier regional study by the same author (Darvill 2004:140-165; Darvill 2010: chapters 4-5, pp122-4).

Optimism for the Past

It is clear that Neolithic human remains need to be reassessed. Human bones record events affecting the people during life. They are therefore the most direct and powerful source of information for studying the human past. Neolithic human remains have suffered from inattention even more than those of other periods because their generally fragmentary and commingled nature has inhibited conventional skeletal analyses.

Two regions in the UK have emerged as having exceptional significance for the study of Neolithic funerary monuments. The importance of Orcadian chambered tombs and the Cotswold-Severn barrows to Neolithic human skeletal studies is illustrated by the quantities of bone recovered from major sites (Table 1). Orkney emerges as the prime area for Neolithic studies because the broader archaeological resource is also exceptionally well preserved. An additional advantage is the persistence of traditional housing and agriculture into recent history, which, though not precisely analogous, permits detailed study of vernacular stone architecture and the ethnography of a traditional rural society subsisting under similar conditions, near to the practical limits of agriculture (Fenton 1973; Fenton 1978; Bowers 1983; Barker 2005).

A brief description of Orcadian Neolithic tombs follows, since these are the sources of most Neolithic human remains. This is followed by a description of the Orcadian environment and its likely effects on Neolithic life.

Table 1. British Neolithic Sites with Ten or More Individuals Recorded (excluding cremations).

SITE	LOCATION	MNI	AUTHOR and DATE of PUBLICATION
Isbister	**Orkney**	**341**[a]	**Chesterman 1983**
Quanterness	**Orkney**	**165**[e]	**Chesterman 1979**
Hambledon Hill	Dorset	75[c]	McKinley 2008
Korkquoy	**Orkney**	**60**	**Petrie MS (Davidson & Henshall 1989)**
Fussell's Lodge	Wiltshire	53	Ashbee 1966
Tinkinswood	Glamorgan	50	Keith, 1916; Ward 1916
Ascott-under- Wychwood	Oxfordshire	46[b]	Chesterman 1977; Benson and Whittle 2006
Hazelton North	Gloucestershire	41	Saville 1990
Parc Le Breos	Gower	40	Lubbock & Douglas 1871, Whittle and Wysocki 1998
West Kennet	Wiltshire	40	Piggott 1962; Wells 1962
Belas Knap	Gloucestershire	36	Crawford 1925
Ty Isaf	Breconshire	33	Grimes 1939
Yarso	**Orkney**	**29**	**Callander and Grant 1934**
Duggleby Howe	Yorkshire	28	Mortimer 1905
Lugbury	Wiltshire	27	Thurnam 1857
Midhowe	**Orkney**	**25**	**Callander and Grant 1934; 1937**
Rowiegar	**Orkney**	**25**	**Grant 1937 (Meg Hutchison pers. comm.)**
Burray	**Orkney**	**22**	**Petrie 1863 (Davidson & Henshall 1989)**
Sale's Lot	Gloucestershire	21	0'Neil 1966
West Tump	Gloucestershire	20	Witts 1881
Eyford, Swell	Gloucestershire	19	Rolleston 1876
Norton Bavant	Wiltshire	18	Ashbee 1970
Nympsfield	Gloucestershire	16	Clifford 1938
Banks	**Orkney**	**15+**[d]	**Lawrence 2012**
Wayland's Smithy	Oxfordshire	14	Atkinson 1965; Brothwell and Cullen 1991
Heytesbury 1	Wiltshire	14	Ashbee 1970
Millbarrow	Wiltshire	14	Whittle 1994
Quoyness	**Orkney**	**14**	**Farrer 1868; Childe 1952**
Point of Cott	**Orkney**	**13**	**Barber 1997**
Rodmarton	Gloucestershire	13	Clifford and Daniel 1940
Pole's Wood East	Gloucestershire	12	Greenwell 1877
West Stow	Yorkshire	11	Ashbee 1970
Pipton	Breconshire	11	Savory 1956
Lanhill	Wiltshire	11	Keiller and Piggott 1938
Windmill Hill	Wiltshire	10	Smith 1965

[a] since revised to 85 (Lawrence 2006);
[b] since revised to 21 (Galer 2007);
[c] including all Neolithic deposits.
[d] perhaps ultimately 80+ overall
[e] likely to be revised downwards

1.4. NEOLITHIC TOMBS IN ORKNEY

Human remains are likely to be deposited in a significant manner (e.g. Ucko 1969; Saxe 1970; Binford 1971; Tainter 1978; Metcalf and Huntington 1991; Parker Pearson 1999). Small quantities are found at Neolithic settlement sites (e.g. Childe 1931; Lawrence 2007; Dockrill 2007), caves (e.g. Chamberlain 1996; Barnatt and Edmonds 2002; Leach 2008; Schulting *et al*. 2010) and causewayed enclosures (e.g. Pryor 1998; Whittle *et al*. 1999; Evans and Hodder 2006) but the most obvious and productive sites to exhibit significant deposition of human remains are the monumental tombs.

The chambered tombs of Orkney have been the subject of detailed and methodical surveys (Henshall 1963; Henshall 1972; Fraser 1983; Davidson and Henshall 1989). The catalogue of Davidson and Henshall lists 81 examples but excludes several possible examples previously listed by Henshall. Fraser listed 78, together with an additional 25 ‘category delta’ (possible but unproven) examples and 14 ‘category epsilon’ (believed to belong to a different monument category) sites. Recent surveys, excavations and ploughing have led to the recognition of additional Neolithic mortuary sites, including Banks, South Ronaldsay (Lee 2011b), Crantit, St Ola (Smith 1999), Sunnybank (Thomas 2009), Appiehouse, Harray (Lawrence 2005), Roeberry, South Walls (Lee 2011a), Sandfiold, Sandwick (Dalland 1999, a.k.a. Sand Fiold) and potentially Swandro, Rousay (Dockrill *et al.* forthcoming).

Orcadian Neolithic tombs (except the rock-cut Dwarfie Stane) share several architectural characteristics. They are built using dry stone walling. They have internal chambers that would have been accessible after construction. They have overlying mounds penetrated by entrance passages and could be blocked by temporary masonry. Other features are common but possibly not ubiquitous: decorative use of stone walling patterns, structural elaborations or enlargement; later partial destruction with use of fire internally and infilling from above. Significant quantities of animal bone are found with the human bone and there are finds of both domestic and non-domestic artefacts.

Forms of Neolithic tombs and barrows have been much discussed, especially in the context of the culture historical approach (e.g. Piggott 1954; Henshall 1963; Davidson and Henshall 1989:85-94). Four main types have been identified within the Orcadian series but there is considerable variation within each (Henshall 1963:45-134; Davidson and Henshall 1985:19-51). Three types have been grouped with similar north Scottish forms as ‘Orkney-Cromarty’ tombs, which are distinguished from a Maes Howe (or Quoyness-Quanterness) type (although other models exist (e.g. Renfrew 1979:208-211; Richards 1988)).

Tripartite tombs are the smallest and simplest of the conventional tomb types in Orkney. They have small circular mounds penetrated by a low passage, which leads to a central chamber divided into three by orthostats.

The stalled cairn appears as a long mound. An entrance passage is either aligned with a central chamber or perpendicular to it. The central chamber is subdivided along its length by opposing pairs of orthostats, leaving the centre open. The side walls are concave between the orthostats, giving a subtle emphasis to the segmented chamber plans, which may alternatively have structural significance (Barber 1992). Side cells may be present, as at Unstan and Isbister. End chambers/stalls tend to have sill stones and large terminal orthostats; they may have monolithic ceilings. Stalled cairns are associated with Unstan Ware.

The Bookan type has a form that may be adapted from tripartite tombs. Bookan cairn itself is sub-circular in plan and about 13m in diameter (Card 2005b). There is a straight narrow passage leading from the southeast into a rectilinear central chamber. This chamber is itself much wider than the passage and was subdivided symmetrically through the use of orthostats. Sill stones divided five peripheral areas (each about 1.3m x 0.9m) from the centre and give an impression that the sides of the central chamber were formed of large evenly sized cists, very similar to the Skara Brae beds. No dating evidence exists for this site but some of the pottery may have Grooved Ware affinities, suggesting some relationship with Maes Howe-type tombs.

Maes Howe (or Quoyness/Quanterness) type tombs are large circular mounds with internal chambers reached along a long low straight passage. Distinguishing features are a lack of subdivision by orthostats, side cells leading from central chambers and the ceilings typically constructed by corbelling. Maes Howe tombs are associated with Grooved Ware pottery, which conventionally has been used to suggest that they were used later than stalled cairns. The Maes Howe mound itself is formed of concentric stone revetment walls with a clay and rubble fill. The long passage into the central chamber and each of the three side chambers occupies a different wall about 0.6m above the central floor, with large cuboid rocks to close it and a horizontal monolithic ceiling. The supposed stratigraphic relationship of a Maes Howe tomb above a stalled cairn at Howe (Ballin Smith 1994:10-25) fails because the earlier structure was more probably a Knap of Howar type settlement (Davidson and Henshall 1989:88).

There are several Neolithic tombs in Orkney that do not fit comfortably within this conventional typology. Taversoe Tuick for example has two storeys and a rock-cut feature; the Dwarfie Stane, Hoy may be the UK's only Neolithic rock-cut tomb. A further class of Neolithic tomb might be identifiable: the rock-sunk tomb or cist. Banks, Crantit, Sunnybank and Sandfiold might all fit into such a category (which could be stretched to include the Dwarfie Stane). Banks, Crantit, Sunnybank and Sandfiold are all constructed within hollows cut down into bedrock and roofed with monolithic horizontally set flagstones (Ballin Smith and Duncan 1998; Ballin Smith 2001; Thomas 2010b; Lee 2011b; Dalland 1999). Each has stone-built structural elements. Sandfiold had an orthostatic cist structure; Crantit was divided into chambers with orthostatic pillars; Sunnybank had dry stone walling to accommodate the steep slope on one side; Banks has a passage and side cells of dry stone walling. Except for Banks, these sites were flat to the ground surface when discovered. This need not imply that they had no associated mounds because material may have been ploughed or quarried away. Crantit, Sunnybank and Sandfiold could represent an intermediate form of tomb leading towards the classic flexed inhumation of the 'Beaker' type, which could be supported by the range of radiocarbon dates from Sandfiold (i.e. the human bones at 2880-2490BC (UtC1485) and 1980-

1740BC (UtC1484) (RCHMS Canmore site entry)).

In a pragmatic sense, Neolithic tombs served to contain the remains of dead people. The form permitted repeated access, which may have been intended to facilitate sequential interment or other activities within the structure. The walls and mounds protect the remains from external forces such as the weather, animal activity or human actions. Internal features such as orthostats, 'benches' or side cells may be interpreted as additional protection or spatial organisation. The side cells and under-bench areas might be construed as ossuaries. The numbers of individuals interred may be significant to further interpretation but it seems that no tomb type dominates in bone density. The most populous Orcadian tombs are of different forms: Quanterness is of Maes Howe type and Isbister is a stalled cairn, whilst Korkquoy may be something different again (see Davidson and Henshall 1989; Table 1 above).

Death and burial are almost inevitably bound up with religious beliefs and practices, so it is very likely that the architecture, deposits and inclusions of the Neolithic tombs had symbolic as well as practical functions. Architecture and decorative carvings have been cited as evidence of contact with Ireland (e.g. Ritchie 1995:21; Renfrew 1979:210). Incised carvings of spirals and concentric circles, especially the densely decorated example from Pierowall, bear similarities to carvings at Newgrange (Neil 1981; Sharples 1985a:104-5). Features in common may indicate contact, influence, a variety of symbolisms or even human experience with psychoactive substances (Crawford 1957; Bradley 1989; Rudgley 1993:19-24; Lewis-Williams and Pearce 2005) but the specifics are debatable (e.g. Fleming 1969; Scarre 1994). Some tombs exhibit decoratively lain stonework (Davidson and Henshall 1989:30-1). Potential meaning is rarely addressed beyond speculative 'New Age' concerns (Biaggi de Blasys 1982; Cope 1998; Cope 2004:58-61; Lewis-Williams and Pearce 2005) but decorative use of stone is not a simple practical element and suggests display. It might have more abstract or magical functions such as restraining or confusing spirits (cf Bendann 1930:57-93; Frazer 1933 etc.). The monumentality and construction effort of many of the sites speak of high prestige or special significance. There seems to be no reason to impose a symbolic death referent to the use of stone itself (*contra* Parker Pearson and Ramilissonina 1998), not least because stone is obviously used for Orcadian domestic sites. The structural properties of stone and soil may nonetheless be generally significant: the tombs conceal, contain, insulate and protect. Large size and prominent location suggest a desire to increase visibility or to increase the level of isolation, or both.

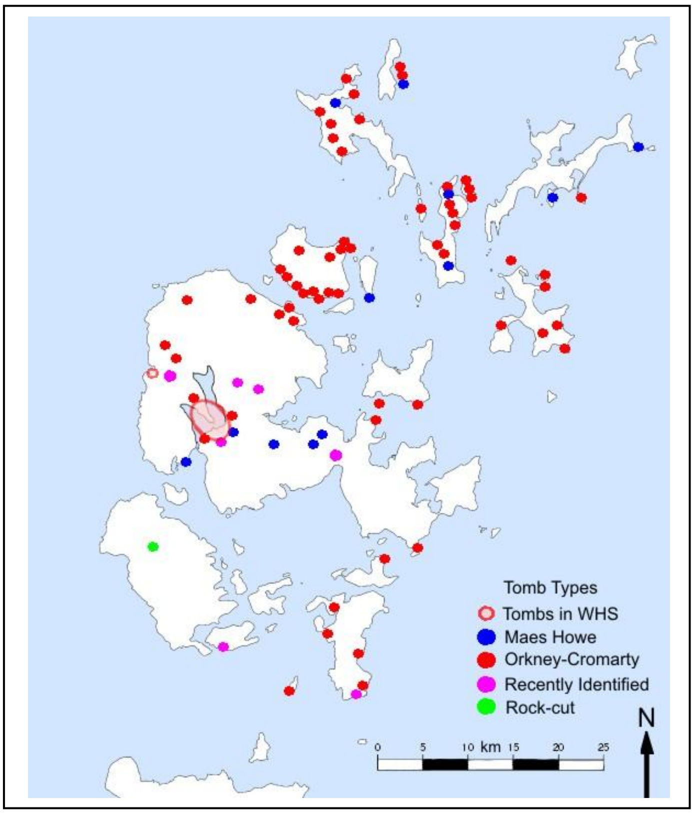


Figure 1. Locations of known Neolithic tombs in Orkney.

The spatial distribution of chambered tombs (Figure 1) may be significant (Davidson and Henshall 1989:15). Location of chambered cairns close to readily accessible building stone has been recognised and may indicate pragmatism (Fraser 1983:324). Rock formations may have had some cosmological significance (Tilley 1994, 2004; Cummings and Whittle 2004) although this is disputed (Fleming 2005) and may not reflect a locational imperative. It might more generally be accepted that they were prominent (on hillsides or headlands (Davidson and Henshall 1989:15)) from particular areas. Notwithstanding high tomb density on Rousay, the close proximity of two such productive tombs as Isbister and Banks (see Figure 20) seems unusual and may be an expression of social distinction or territorial change.

Thiessen polygons are perhaps the most common tool for investigating territorialism but such studies require assumptions of contemporaneity and may fail to comprehend local topography. Phillips suggested that the distribution implied a lack of concern with the marine environment (Phillips 2002, 2003). Woodman (2000) suggested that a view of or from the sea could be important but this would be difficult to avoid in Orkney. On the Black Isle, tombs were in elevated locations on hillsides overlooking settlement sites (Phillips and Watson 2000). Intervisibility between monuments and landscape features has been explored for Neolithic cairns in north-east Scotland and the Irish Sea Zone but visibility from transportation routes or settlements might be more important than from other tombs (e.g. Bakker 1976, 1991; Criado Boado *et al*. 1994; Criado Boado and Vázquez 2000; Baldia 1995:15.2; Phillips 2002:298; Cummings 2009).

Chambered tomb construction requires a major expenditure of energy, probably by a whole community and so it must be assumed that the tombs were important to some group in the community or at least to their leaders (e.g. Binford 1971). Since the tombs contain multiple individuals, often in disarray, they were not mausolea created for single high-status individuals but could have been family tombs. Tomb forms permit access and suggest that protection of intact remains in perpetuity may not have been intended. The apparent chaos of deposition has been used to suggest secondary reburial but such an interpretation may not prove universally tenable (Lawrence 2006). The social system suggested by communal burial in chambered tombs has been assumed to be egalitarian, with individuals treated equally in death as they were in life; the tomb and its contents a communal link to the past that anchored a community in its landscape and demonstrated territorialism (e.g. Renfrew 1976; Hodder 1984). Such an egalitarian interpretation is contradicted because few of the excavated tombs contain enough bones to be the remains of a complete community over any great length of time. The alternative is that there was selection of the individuals that were to be interred. The tombs may reflect a very short period when interment was the normative rite and a short period of interment has been suggested by Bayesian modelling of radiocarbon dates from English monuments, for which the longevity in Orkney was seen as exceptional (Meadows *et al*. 2007; Whittle *et al*. 2007; Bayliss *et al*. 2007a,b,c). This model may be undermined by the wide distribution and use of such monuments, unless some were or became merely symbolic. Extensive remodelling of some earthen barrows and megalithic tombs demonstrates continued interest and suggests they were used over an extended period. This is supported by the potentially long range of radiocarbon dates from Isbister (Renfrew *et al*. 1983). It is perhaps more likely then that the interments in an Orcadian tomb at least are from a special group over a longer period. This would explain both multiple inhumations/cremations and monumentality of the structures, potentially remaining consistent with theories linking the tombs to territoriality. In this model, the existence of several tombs in close proximity might indicate distinct successive or contemporary elites treated in an archaic manner.

A major deficiency in examining Neolithic tombs in Orkney derives ironically from their excellent preservation. Major structures are usually left *in situ* and consolidated for public display. Few sites (especially tombs) have been totally excavated. We rarely know what lies within or beneath the masonry. In Orkney, Point of Cott and Sandfiold are the only tombs to have had complete controlled excavation (Barber 1997; Dalland 1999). There is evidence of earlier structures and deposits in rare cases (e.g. Ballin Smith 1994), evidence of ground preparation (possibly earlier agriculture) and internal wall structure has also occasionally been discovered (e.g. Childe 1954, 1956; Lee 2011a). There may be further value in examining the immediate surroundings of tombs in greater detail as well as the obvious monuments to better ascertain external factors.

Chambered tombs present radiocarbon dating difficulties because of unclear depositional sequences, potentially coupled with long use. The radiocarbon calibration curve between 3500 and 3000BC describes a major plateau that makes discrimination within this period impossible without additional information. The nature of the material dated from Orcadian Neolithic tombs presents further complexities. Radiocarbon assays are typically undertaken on bone samples, which provide estimates for the lives of the individuals interred rather than terminal dates that could be related to the structures with any confidence. Recently published dates from Holm of Papa Westray North (Ashmore 2009:59-66; Schulting and Richards 2009:66-74) suggest two distinct periods of human bone deposition in the tomb in the mid 4th millennium BC, *c*3640-3340, and late 4th/early 3rd millennium BC, *c*3340-2890 BC respectively, with animal bones arriving later in the third millennium BC, *c*2880-2470. Quanterness had human bones from the late 4th millennium but internal pits had bone from well into the third as well as presumably redeposited earlier material (Schulting and Sheridan *et al*. 2010). Broadly similar date distributions are exhibited by all types of Orcadian chambered tombs examined and animal bones found in them often seem to be mid-late third millennium (e.g. Cuween, Point of Cott: Scottish Radiocarbon Database records). Partial destruction of the tombs in the late Neolithic has only been securely dated at Pierowall Quarry (GU1583: 2890-2500BC and GU1584: 2900-2350BC provide *termini post quem* (Sharples 1985a:86; Stenhouse in Sharples 1985:90; Scottish Radiocarbon Database record)); tomb construction dates in Orkney remain unknown.

Difficulties in distinguishing between continuity, reuse and redeposition are problematic for interpretation. Deposition in the mound, fill and chambers could be intrusive relative to the supposed primary use phase. One recent example is Roeberry Barrow, which has both Bronze Age and Iron Age remodelling and burial above a Neolithic monument (Lee 2011a), another is Quanterness, where apparent stratigraphy and association of skeletal elements were contradicted by radiocarbon dating (Schulting and Sheridan *et al*. 2010). Stratigraphy within chambered tombs reflects latest deposition rather than interment

The designs of monumental barrows may derive ultimately from the Neolithic European longhouse (Reed 1974; Hodder 1984; Midgeley 1985, 2005:77ff): similar timber halls have been recorded in Scotland (e.g. Brophy 2007). Although this may reflect mere architectural similarity rather than descent, echoes of domestic architectural forms in Orcadian tombs (see Figure 2) seem likely to be analogous to the European counterparts, although the opposite derivation, from tomb to dwelling, has also been suggested (Richards 1993, 1998). Evolutionary models have been proposed for the development of the Orkney-Cromarty tombs, in which the simple tripartite forms are earliest, with the other forms developing later (e.g. discussed by Davidson and Henshall 1989; Renfrew 1979). There is some reason to suggest a chronological relationship between Maes Howe- type tombs and Orkney-Cromarty forms because of the associations with distinct pottery types: Grooved Ware and Unstan Ware respectively. Attention has been drawn to the confusion of the radiocarbon dating evidence (Schulting and Sheridan *et al*. 2010) but the pottery forms themselves had a stratigraphic relationship at Pool, which supports the diachronic hypothesis (Hunter and MacSween 1991) but could reflect replacement.

The association of stalled cairns with Unstan Ware and of Maes Howe-type tombs with Grooved Ware appears to hold broadly true. Despite potentially lengthy periods of use, stalled cairns rarely have Grooved Ware deposited and this has been used to suggest that there were two distinct societies living contemporarily in Orkney, intermingled geographically but each with a distinct pottery, house and tomb form (Hedges 1984:114ff). Isbister and Unstan are both hybrid tomb forms, containing side cells as well as chambers, so they may be a development from the pure stalled cairn architecture. Both contained Unstan Ware, which conventionally implies a relatively early date but Isbister also held a small quantity of Grooved Ware (Henshall 1983:43).

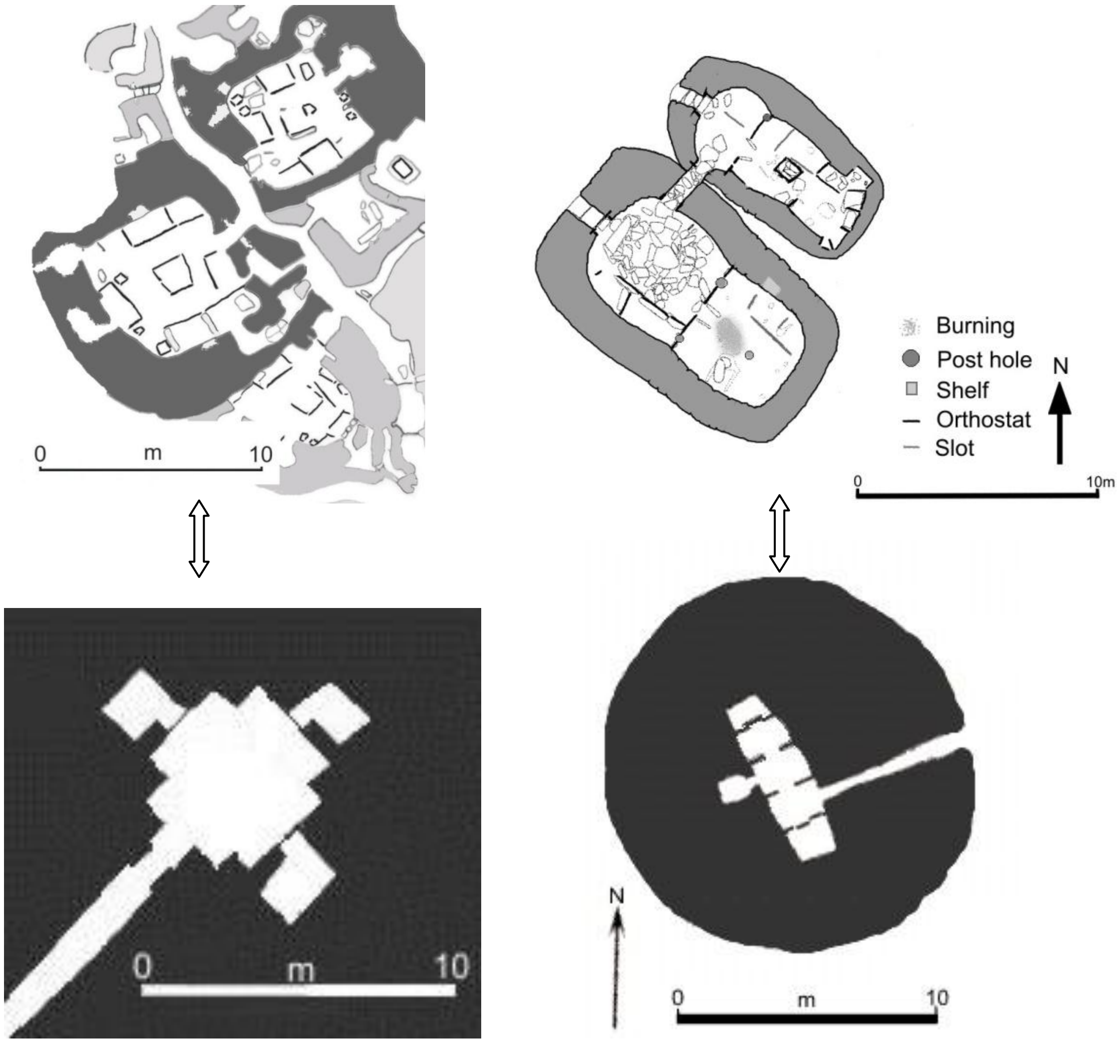


Figure 2. Unstan and Grooved Ware associated settlement and tomb forms.
Left side: Grooved Ware associations; right side: Unstan Ware associations.
Clockwise from bottom left: Maes Howe, Skara Brae houses 1 and 5, Knap of Howar, Unstan (after Davidson and Henshall 1989; Childe 1931; Ritchie 1984).

If the simplest tomb forms were early and contain few individuals then perhaps more elaborate tombs were not necessarily late in origin but continue in use longer and were remodelled. Continuity of use could have required assumption of roles previously played by other monuments, as a result of increasing political or religious centralisation. Unequal tomb longevity might suggest a reason for greater numbers of bones contained in certain tombs, explaining the presence of both Grooved and Unstan Ware at Isbister.

Understanding of Neolithic Orkney is more limited than the quality of surviving archaeological remains would suggest. Despite a tendency of secondary publications to misinterpret sources however, there seems little value in merely adding to speculative literature by reanalysing the known monuments without contributing new information. There is clearly considerable potential in new analyses of human remains, which have been underused.

The following section describes the environment of Orkney, to place Neolithic people in their immediate context and provide the background to Neolithic Orcadian life.

This is a difficult land. Here things miscarry

Whether we care, or do not care enough.

The grain may pine, the harlot weed grow haughty,

Sun, rain, and frost alike conspire against us…

Edwin Muir, The Difficult Land

1.5. The Natural Environment of Neolithic Orkney

Orkney and Climate

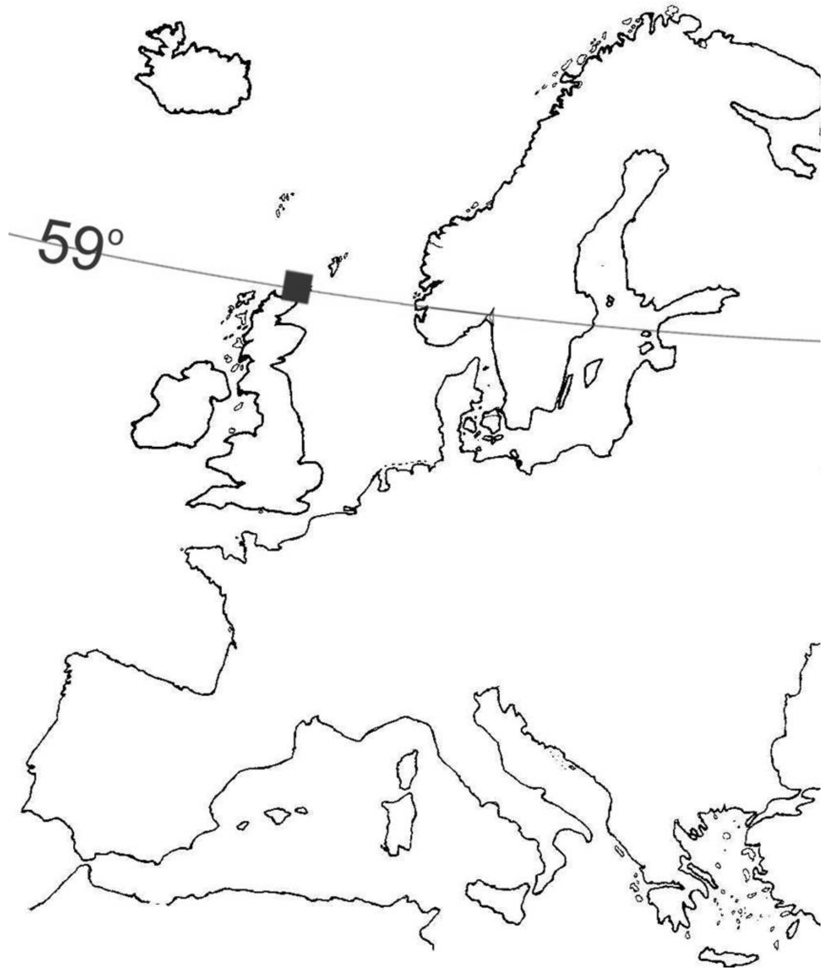


Figure 3. General location of Orkney in Europe.

Orkney is an archipelago consisting of approximately 70 islands, at 3ºW 59ºN, between the North Sea and the Atlantic Ocean, to the north of Great Britain (Figure 3 above). The inhabited landscape is formed of small low-lying landmasses surrounded by ocean waters and Orkney has a greater degree of environmental constraint to life than most regions at lower latitudes or on larger areas of land (e.g. O'Dell 1935). This facilitates the identification of variables for archaeological interpretation.

Neolithic Orkney may have been different from today climatically, vegetationally and even in relief. The Neolithic is bracketed by ice raft debris events (related to periods of significant ocean surface temperature change) identified in sediment cores from the North Atlantic (Bond and Lotti 1995; Bond, G. *et al.* 1997). They may be indicative of disturbances to the Atlantic conveyor and particularly to the expansion and break-up of surface ice, possibly cessation of the Gulf Stream. Temperature changes at these times are also indicated by $\delta^{18}O$ values from Greenland ice cores, suggesting a warm period (e.g. Johnsen *et al*. 2001), possibly related to variations in solar winds (Bond, G. *et al*. 2001). Generally however, models relating such variables to wider environmental conditions may be inapplicable to Orkney's low-lying hyperoceanic location and its susceptibility to the Gulf Stream.

There is little direct climate evidence from Neolithic Orkney. Orkney today is warmer than comparable northerly regions, because the Gulf Stream brings warm water across the ocean as part of the Atlantic conveyor. Lack of natural shelter permits exposure to a significant wind-chill factor (e.g. Davidson and Jones 1985:17-19). Fish bones from excavations of Neolithic settlements have been used to suggest that some species had a more northerly range than they do today because of warmer sea temperatures (Davidson and Jones 1985:27).

Orkney and the Sea

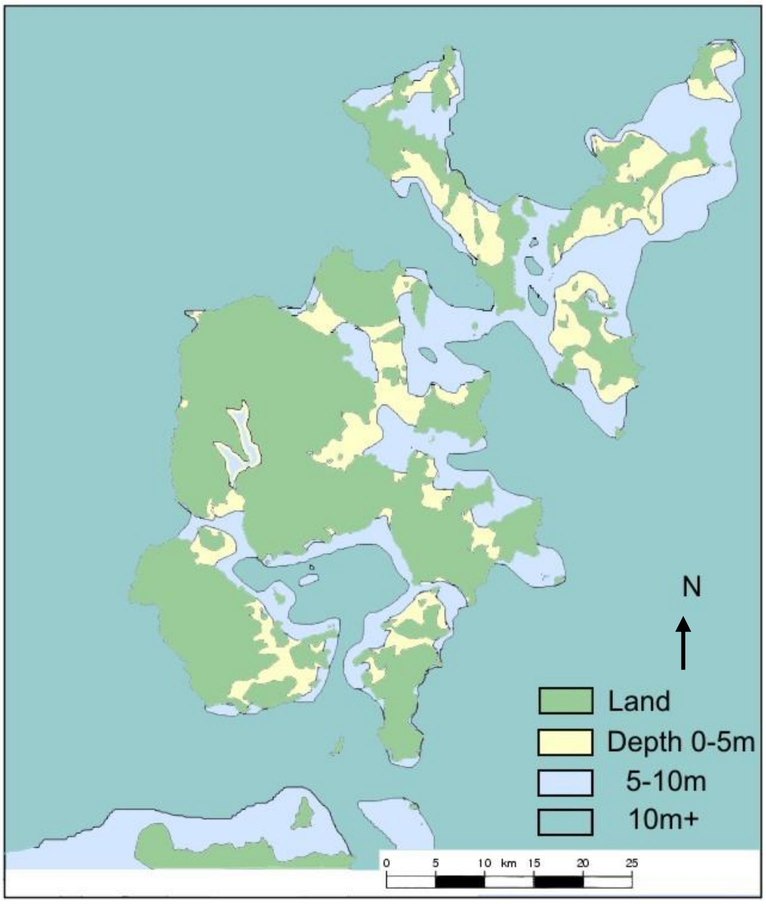


Figure 4. Simplified bathymetry around Orkney.

The tidal range in Orkney is relatively small: 1.2m at small neaps and 4.1m at exceptional spring tides, with further variation according to air pressure and surges (OIC 2011). Tidal currents can be very strong, especially in the Pentland Firth, at up to 9 knots about 3 hours after Dover high water (OIC 2011). Although the sea is often perceived as a barrier, it is also a communications route and a valuable resource for hunting fish and sea mammals.

Post-glacial isostatic and eustatic processes continued through the Neolithic so that sea level changed continuously in Orkney (Smith *et al*. 1996) but may have involved localised variation. Most sea level change models are constructed on the basis of observations at the Argyll coast, imposing uniform circumferential variation but there has been little evidence from the North of Scotland to test the accuracy of these models (however note Dawson and Smith 1997). There have been suggestions that relative sea-level in Neolithic Orkney was within the modern tidal range (Fraser 1983:25-30) but a value *c*5m lower has been suggested (Lambeck 1995). Submerged willow shrubs found beneath a beach on Sanday, at -1.6mOD and dated by radiocarbon to 4720-4540BC (Rennie 2006:117ff) suggest a lower relative sea level. The possible presence of structures at about 7m below sea-level, suggest that it was lower still (Wickham-Jones *et al*. 2009:130). The most recent sea level curve for Orkney suggests a relative sea level about 1m below Ordnance Datum at 4000BC - approximately 1.5m below the modern low water line (Bates *et al*. 2011:fig.13). Diatom analysis of cores from Stenness Loch (Mainland) and Echna Loch (Burray) and underwater sidescan sonar surveys supported by ground-truthing by scuba divers (Wickham-Jones *et al*. 2009) suggests that relative sea level did not approach its current level in Orkney until the late Neolithic c2600BC, although it then continued to rise before receding. Recent work on the southern shore of Rousay at Swandro suggests that even in the Iron Age it was possible to create substantial midden deposits in coastal locations that are now well below the beach surface in the intertidal zone (Dockrill 2011; Dockrill *et al*. 2011). A lower relative sea level may have exposed extensive coastal plains, possibly joining some of the northern Isles and reducing the area of Scapa Flow (see Figure 4). It is likely that the chain of southern isles from Lamb Holm through to South Ronaldsay at least were attached to each other, though possibly not to Mainland. Sea cliffs were probably in similar locations to their current distribution but tidal currents, erosion and deposition will have been affected.

Orkney's coast is a high energy environment with considerable erosion and deposition of sand, beach pebbles and large quantities of seaweed. Such events relate particularly to wind strength and direction. Sand movement is affected by vegetation, with resultant dune formation or 'blow out' and deflation. These features have been recorded archaeologically (Davidson and Jones 1985:25-6) and are of particular importance at the prehistoric landscape at Links of Noltland, which has recently been exposed and is suffering erosion after millennia of protection by deep sand (Figure 5 below). Erosion will have affected the coastline and the bathymetry around Orkney: scour may have deepened and widened channels between islands.

Deposition at the coasts has led to the formation of substantial storm beaches, which may retain water to form lochs such as Liddel Loch on South Ronaldsay (ND453833) and Echna Loch on Burray (ND473967).

Figure 5. Severe dune deflation exposing prehistoric remains at Links of Noltland, Westray 2005.

Latitude and Insolation

Sunlight varies regularly in two distinct but parallel ways. Firstly the amount of time that the sun is above the horizon and secondly the angle of incidence of the sun's rays (described by Figure 6 below).

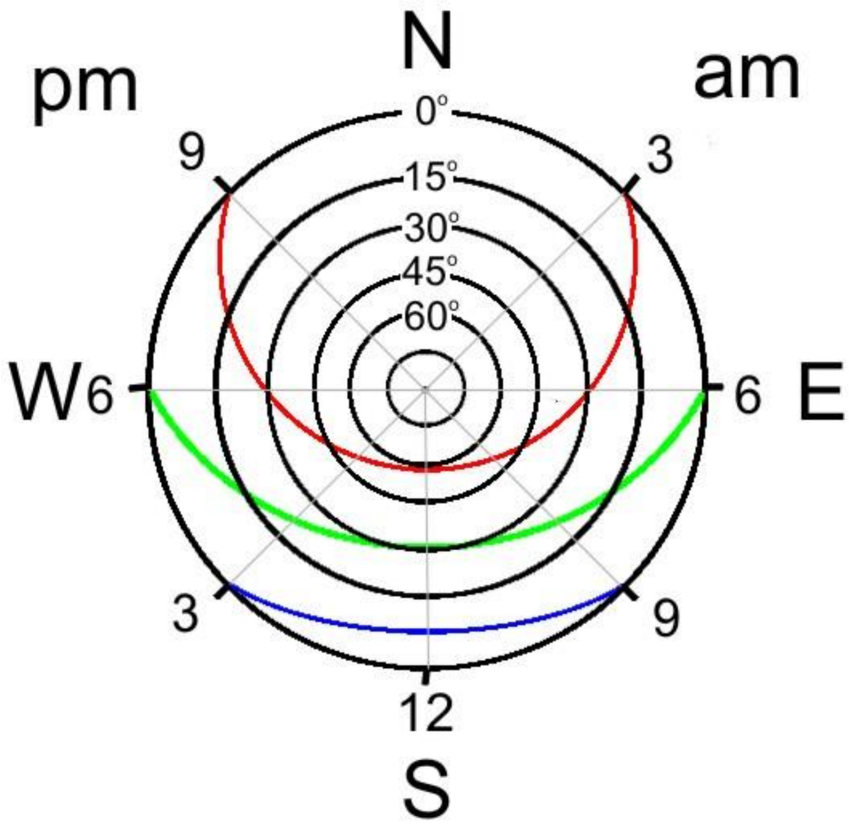


Figure 6. The path of the sun as seen in Orkney at different times of year (after Berry 2000:10).

Letters signify cardinal points: N (north), S (south), E (east) or W (west).

Numbers around the circumference indicate time of day, e.g. 9 o'clock.

Numbers in degrees indicate altitude above the horizon in 15° increments.

Winter solstice Equinoxes Summer solstice

In midwinter Orkney the sun rises above the horizon in the south-east at about 9am and sets in the southwest at about 3pm, never rising to 15° above the horizon; in midsummer, the sun rises in the north-east at about 3am, rises to almost 60° (in the south) at mid-day and sets in the northwest at about 9pm (Figure 6). This produces a marked seasonality that affects plant growth and climate (Figure 7). It also affects exposure to ultraviolet light with potential consequences in humans for vitamin D and seratonin production.

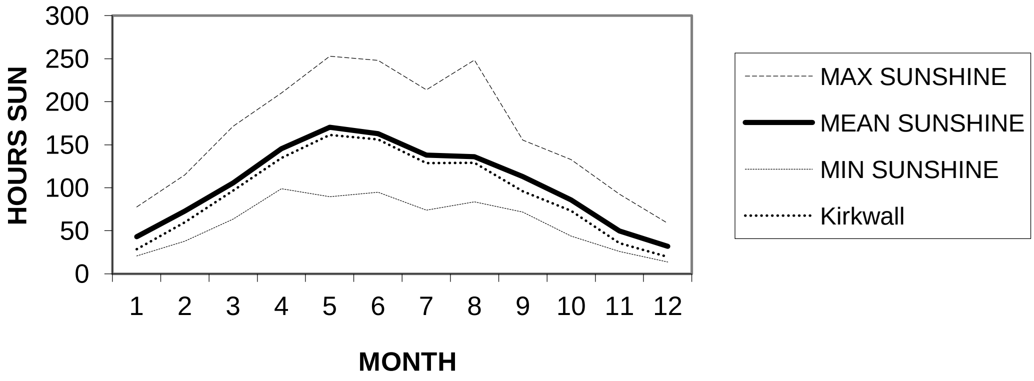


Figure 7. Variation in mean total monthly sunshine at Wick (1946-1993) (data from http://www.metoffice.gov.uk/climate/uk/stationdata/wickdata.txt). Thirty year (1961-1990) mean values for Kirkwall are slightly lower than the Wick means, especially in autumn and winter, but follow an identical pattern.

Low vitamin D in childhood causes rickets and in adults osteomalacia, which are recognisable osteologically (Ortner 2003:393-404). A low childhood level of vitamin D is also linked to multiple sclerosis, for which Orkney has the highest prevalence in the world (Poskanzer *et al*. 1980; Visser *et al*. 2012). Humans require relatively little exposure to sunlight to form vitamin D provided that the precursors are present; a so-called 'Viking gene' may suppress the ability but its presence remains unproven (e.g. Ebers 2008). Dietary vitamin D may be significant in circumstances where heavy clothing or an indoor lifestyle inhibit exposure to sunlight but rich sources are few, notably fatty fish, eggs, liver and dairy products (Bender and Bender 1997:245ff). Short photoperiods can also cause seasonally affective disorder (e.g. Lam and Levitan 2000). Natural light levels are likely to have influenced the layout of buildings. Doorways will have normally been exploited to illuminate indoor activities, although at Skara Brae, they were probably subterranean; fires, tapers or lamps are likely to have been used when suitable raw materials were available.

Light is essential for photosynthesis and therefore for green plant growth. Sunlight is also related to air temperature (see Figure 8), so there are further effects on plant development and needs for warm clothing. With great variation in insolation period, Orkney therefore has a very short growing season.

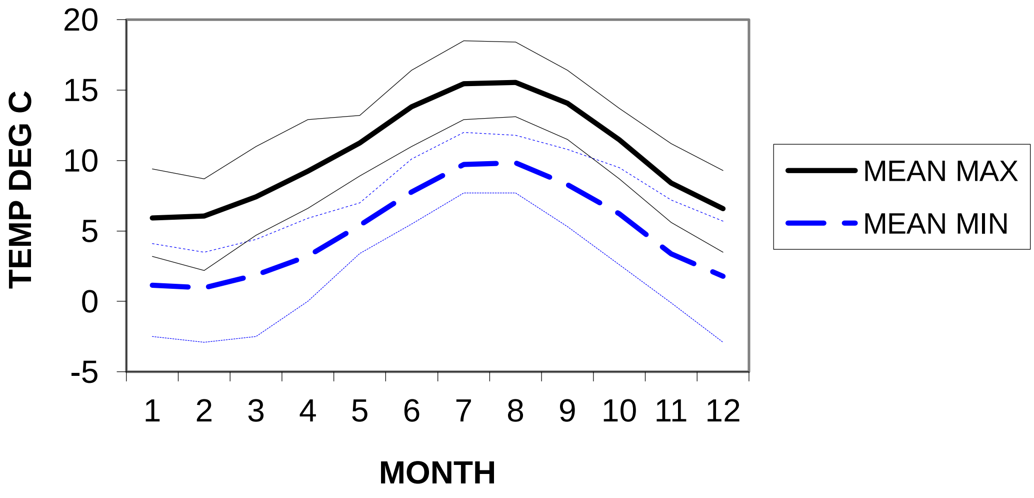


Figure 8. Variation in mean monthly air temperature at Wick (1914-2011 data from http://www.metoffice.gov.uk/climate/uk/stationdata/wickdata.txt), showing maxima, minima and extremes.

Orkney is more exposed than Wick but temperature changes are ameliorated, so Kirkwall averages 0.2˚C cooler than Wick in summer but 0.1 ˚C warmer in winter.

Wind

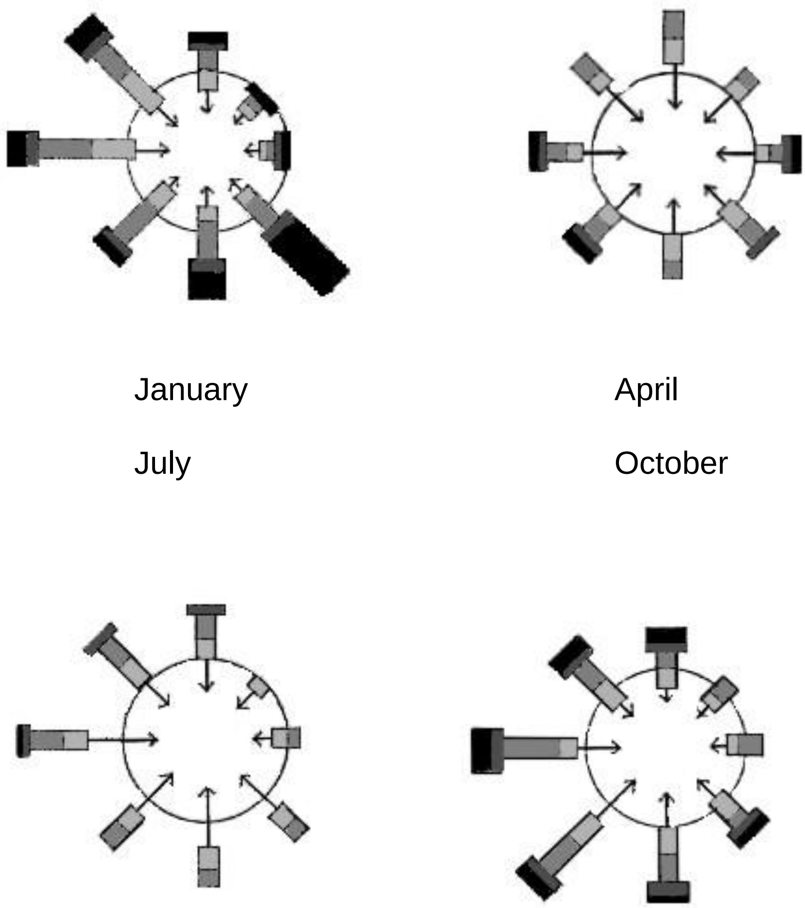


Figure 9. Wind roses for the different seasons in Orkney
(after North Coast of Scotland Pilot, Hydrographer for the Navy N.P.52 1975).
The length of each segment is proportional to the amount of wind at different strengths from the different directions.
→ Force 1-3 ◻ Force 4 ◻ Force 5-6 ◼ Force 7 ◼ Force 8+

The exposure of Orkney to the Atlantic Ocean and North Sea results in strong autumn and winter winds (Figure 9). The prevailing westerlies have a fetch of *c*5000miles (8000km), so can be very strong and drive heavy seas. Winds are rarely from the northeast but these are bitter. Gales may occur at any time of year and from any direction. Wind-chill is significant all year round, requiring heavy clothing, shelter, house insulation and heating for comfort if not survival.

Agriculturally this results in exposure of crops, not merely to the wind but to driven precipitation, sand and salt. These have adverse effects, damaging crops, soils or homes by abrasion, deposition, erosion and causing leaf burn.

Orcadian houses (e.g. Figure 10 below) have traditionally been constructed to minimise exposure. Openings in walls are usually small, though larger on south facing walls to admit sunlight. Doors tend to be oriented away from prevailing winds, especially in exposed areas, fortunately allowing the houses to present a shorter side to the prevailing westerlies, maximising exposure to the sun's warmth. It is common to shelter doors by carefully siting outbuildings, whilst Skara Brae was largely subterranean in its later phases. Roofs need to be carefully maintained and, traditionally, the materials were tied down with ropes or netting. Walls have historically been thick (75-90cm), built of stone with a clay core.

Figure 10. Nineteenth century farmhouse, Birsay, Orkney: southern aspect.

Precipitation

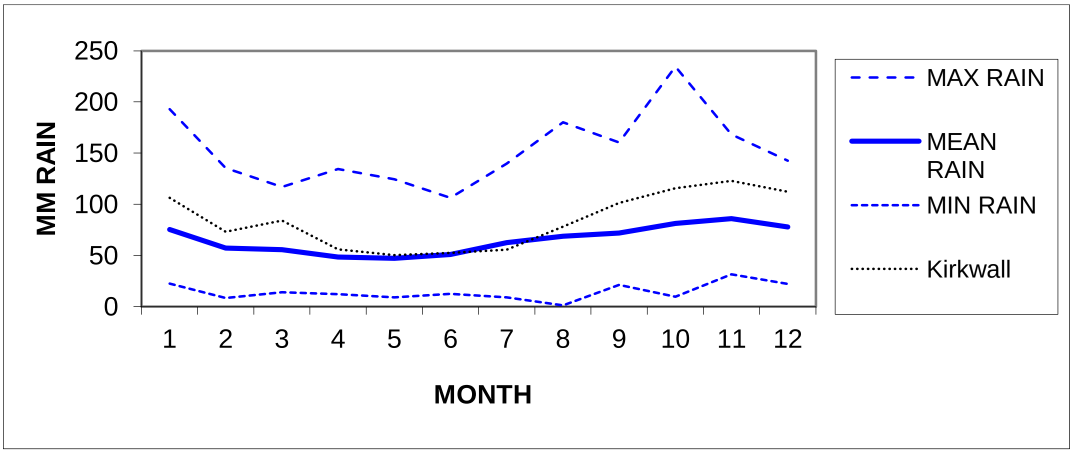


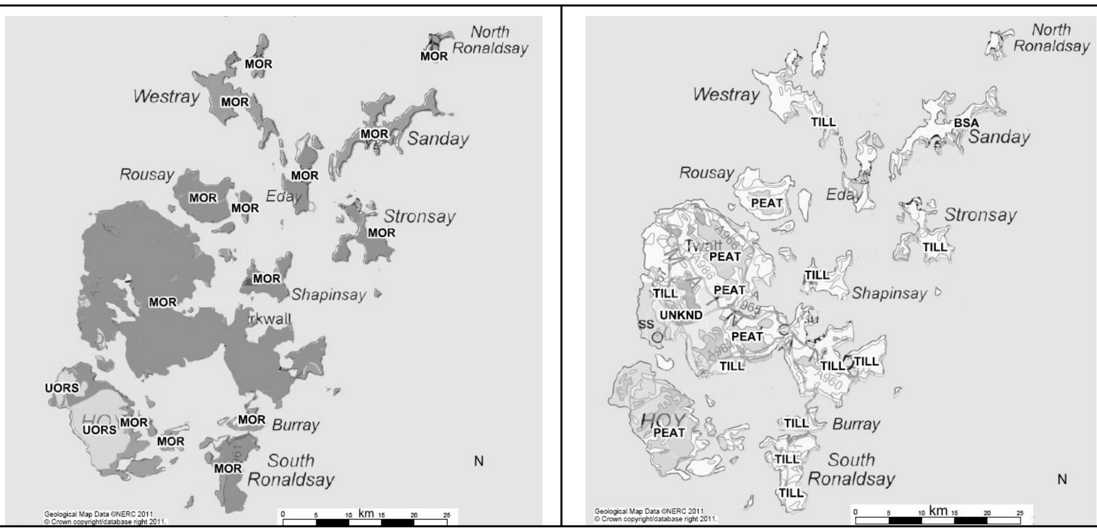
Figure 11. Mean monthly rainfall at Wick (1914-2011 data from http://www.metoffice.gov.uk/climate/uk/stationdata/wickdata.txt).

Mean rainfall is shown for Kirkwall 1961-1990: the slightly greater average autumn and winter precipitation results from the absence of a rain-shadow in the archipelago.

The mean annual precipitation in Orkney is 1009mm, usually reliable and distributed evenly through the year (Figure 11) as rain. Differences between Wick and Kirkwall arise because of the relative shelter from the landmass of Great Britain.

Geology

Orkney's solid rock consists predominantly of flags of Old Red Sandstone (Mykura 1976; see Figure 12). Their granularity varies from mudstone to sandstone. There are occasional igneous dykes and there is a granite deposit in a limited area around Stromness. Flint and chert can be found in several places in Orkney (Wickham-Jones and Collins 1978) but are of poor quality for working into tools. Neolithic flint artefacts in Orkney may therefore be archaic in form (Lacaille 1954:269-274). The sandstone bedrocks cleave readily into blocks and slabs, so that stone building technology has been exploited in Orkney from early times, making up for the lack of good local timber. Reliance on stone, alongside limited agricultural exploitation, has contributed to remarkably good preservation of archaeological sites.



SOLID GEOLOGY CODES		SUPERFICIAL DEPOSIT CODES	
MOR	Middle Old Red Sandstone	PEAT	Peat
UORS	Upper Old Red Sandstone	BSA	Blown Sand
		TILL	Till
		UNKND	Unknown Deposit

Figure 12. Simplified geology of Orkney (NERC 2011).

a. Solid geology b. Drift geology

Numerous faults run through Orkney, creating the outline of the islands, coastal cliffs and relief. The combination of faulting with glacial erosion of the underlying Old Red Sandstone has resulted in a gently rolling landscape. The drift consists predominantly of glacial tills although there are small areas of peat and machair. Drift deposits are often so thin that they are not marked on geological maps. The clays are fertile but heavy to work, so that coastal machair was historically preferred for agriculture (Clouston 1927:205). Coastal agriculture had the advantage of access to large volumes of seaweed used as fertiliser and calcareous sand, used for soil improvement.

Seasonality and Agriculture

Orkney is subject to severe weather conditions. Frost may occur at any time from November until April but rarely lasts long. The numbers of gales, hours of daylight and of bright sunlight show great seasonal variation (see Table 2 below).

Table 2. Seasonal Variation of Major Weather Factors (after Berry 2000).

Mean	Daylight daily	Bright sunlight monthly	Gales monthly
Summer	18 hours	173 hours	0.3
Winter	6 hours	22 hours	5.6

The agricultural year in Orkney is therefore highly seasonal: only 5-6 months, compared with 9 months in England. Harvests are susceptible to catastrophic loss from storms, while drying and ripening are uncertain; animal fodder is also affected.

On 28th August 2011, the cereal crops were not fully ripe and harvest had not begun. Daytime temperature was 10°C but there were 60kmh^{-1} steady winds (gusting more strongly) and there was 98mm rainfall over 24 hours (personal observation). The local bere barley crop was flattened (Figure 13 below). Lying on the ground, grain was much more difficult to harvest and, failing to dry easily, was more susceptible to fungal infestation and rotting. Although modern barley is bred to be short-stalked and fast growing, treated with pesticides, herbicides and fertilisers, it remained unharvested until the end of September in Orkney. By the time that the barley crop was ripe however, part of it was already rotting in the fields and some was sprouting. Whilst hand-reaping would not present the same problems as modern machinery (becoming clogged by damp barley or bogging down in a wet field for example) it would undoubtedly be particularly strenuous under these conditions. The 2011 bere, specially grown for a local watermill, was not harvested until mid October. Harvested barley today is almost universally treated with propionic acid as a preservative but historically would have been dried in special kilns.

In 2012, a dry spring led to late planting; a poor summer inhibited growth and ripening; and finally a wet, windy autumn destroyed some crops and prevented harvesting of some fields well into November. Wheat and oat crops failed completely and some West Mainland farmers wrote off their barley. The East was less affected (Orkney Farmer 2012 5:9), which was fortunate since farmers will have little grain stored, possibly insufficient to last until spring pastures are available.

Figure 13. Bere (L) and barley (R) crops in adjacent fields, Birsay, Orkney 31st August 2011.

There are clearly dangers inherent in reliance on agricultural produce in Orkney but effects are not uniform under all conditions. Natural resources may help to feed animals and humans but are themselves highly seasonal in availability.

Vegetation and Natural Organic Resources

Our knowledge of Orkney's Neolithic vegetation is largely based on a small number of peat core studies (Keatinge and Dickson 1979; Bunting 1994, 1996; Farrell 2009), supported by flotation evidence from archaeological deposits (Clarke 1976a; Shepherd 1996; Hunter 2007; Dockrill 2007).

Evidence from settlement site plant macrofossils is primarily derived from human exploitation activities and may include imported items (e.g. Bond 2007b:154-162; Bond 2007d; Hinton 2005). Wheat, barley and ruderals indicate cultivation (e.g. Bond 2007d:188-190). Heather and small wood artefacts were found at Skara Brae (Clarke 1976a), heather and moorland berries at Pool (Bond 2007d:198-9, Table7.1.2), evidence of pondweeds, seaweeds and marsh plants at Tofts Ness (Bond 2007b:160). Hazelnut shells and a crab-apple pip were found at Barnhouse (Hinton 2005:340).

Machair landscapes, which exist locally today especially in the Northern Isles, are difficult to assess because they are susceptible to erosion and redeposition. For example sand accumulated at the Bay of Skaill from around 4950 BC (De La Vega Leinert *et al*. 2000). One land snail study has suggested that Orcadian Neolithic sandy soils were significantly richer in nitrogen than their Hebridean counterparts (Evans 2004). Fossil snail and diatom evidence suggests the presence of freshwater marsh/pond with later peat growth in the Mesolithic/early Neolithic beneath the beach at the modern Bay of Skaill (De La Vega *et al*. 1996). A similar sequence with lagoon formation was recorded at Scapa Bay (De La Vega and Smith 1996).

Neolithic pollen evidence from Orkney is poor. Peat is widespread in upland areas today but blanket growth is believed to have occurred mostly from the end of the Neolithic onwards (Davidson *et al.* 1976; Berry 2000:70). Analyses may examine unusual areas that are uninformative for ancient human activity and may not include Neolithic remains (Moar 1969; Rackham *et al*. 1989:44; Bunting 1996; Blackford *et al*. 1996). Some samples are highly site-specific (Godwin 1956; Caseldine and Whittington 1976; Davidson *et al*. 1976; Jones 1979). There is considerable promise in the recent work at Blows Moss, South Ronaldsay and Hobbister Hill, St Andrews, Mainland (Farrell 2009). Interpretation however is limited by the small number of radiocarbon determinations for the cores, which requires interpolation and extrapolation to identify Neolithic remains.

Neolithic Orkney seemingly had few mature trees and identified tree pollen - usually willow or alder – may rather have been scrub (Keatinge and Dickson 1979). Access to timber is indicated by the presence of post-holes and potentially some timber buildings (Ritchie 1976; Dockrill 2007; Thomas 2011); there have been reports of layers of acorns near Kirkwall Airport (J. Hamilton pers. comm.). Trees were apparently present at the very beginning of the Neolithic (Farrell *et al.* forthcoming) but were rapidly lost, probably due to human and domestic animal activity, and have never recovered. Nowadays, trees will grow, not necessarily well, where they are sheltered from the winds and from grazing animals but protection from animals was difficult prior to the introduction of wire fencing. It is not impossible that Neolithic wood management occurred, associated with a pattern of rights and obligations but historically timber was imported or collected as driftwood in some areas. Archaeologically, driftwood collection has been suggested at Skara Brae (Clarke 1976a; Clarke 1976b:244-5).

The evidence intuitively indicates a mosaic landscape of moor, marsh, arable, brush, machair and coastal heath but there is some distortion because of the nature of appropriate sampling sites. It is particularly wind, seasonality and the sea that define Orkney's natural environment. Neolithic Orkney will have presented a combination of opportunities for exploitation but also numerous difficulties to be overcome.

1.6. SETTLEMENT EVIDENCE AND SUBSISTENCE

"*The prehistoric Scottish evidence for housing and its structural elements, including the plan-forms and the nature of the hearth, has never been fully assessed,*"

Alexander Fenton 2003:9

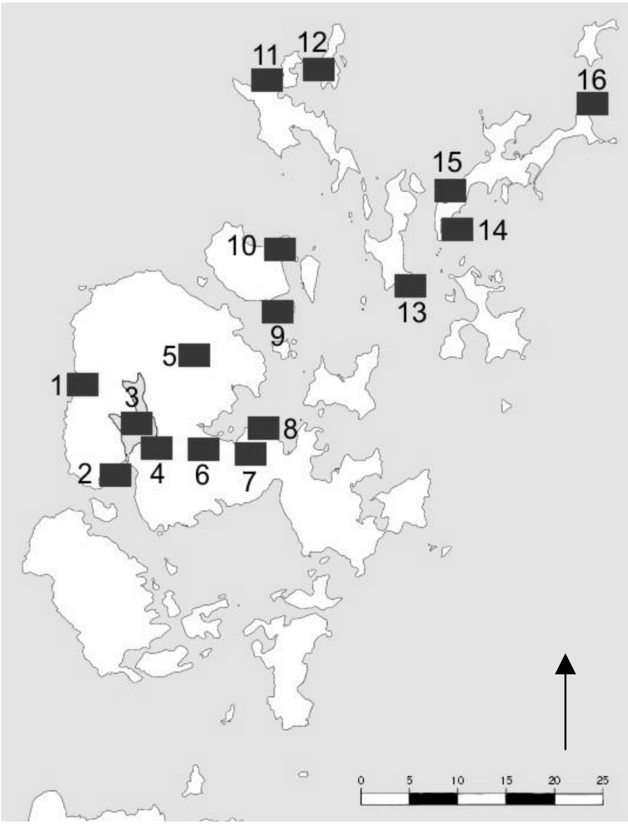


Figure 14. Orkney, showing known Neolithic settlements.

Neolithic settlement

1 Skara Brae
2 Howe
3 Ness of Brodgar
4 Barnhouse
5 Knowes of Trotty
6 Stonehall
7 Wideford Hill
8 Crossiecrown
9 Braes o Ha'Breck
10 Rinyo
11 Links of Noltland
12 Knap of Howar
13 Green
14 Stove Bay
15 Pool
16 Tofts Ness

Neolithic settlements can be readily interpreted as functional. They provide security, shelter and storage space in a manner that accommodates pre-existing conditions: i.e. form meets the needs of the inhabitants (e.g. Rapoport 1969; Oliver 1987), related to availability of resources, local climate and topography. Houses in most small 'traditional' communities tend to be variations on a conventional model, incorporating cultural factors, including building traditions and requirements for social interaction, privacy, prestige, cooking habits, husband-wife interactions and child-rearing, ceremonial and religious requirements; even such elements as supposed good fortune. In addition to providing an element of human experience, details of house and settlement structure may be linked to features that can be observed in the human skeletal assemblage, especially palaeopathology but also stature and diet. A major difficulty lies in the interpretation of archaeological evidence without simply imposing a preconceived model.

Orkney's Neolithic settlements present a picture of small regular stone buildings with central hearths, suitable for use as family homes. The old picture of coastal settlement is being revised by the discovery of inland sites, sometimes in elevated positions (Richards and Jones 1994, 1995; Card and Downes 2005:97; Thomas 2007, 2008, 2009, 2010). Unstan Ware pottery is associated with sub-rectangular structures that have orthostat divisions separating the house into two or three parts, accentuated by slight internal concavities in the walls (e.g. Figure 15). Grooved Ware is associated with squarish or circular houses that appear cruciform internally, with side cells (e.g. Figures 16, 17) and that are assumed to be later.

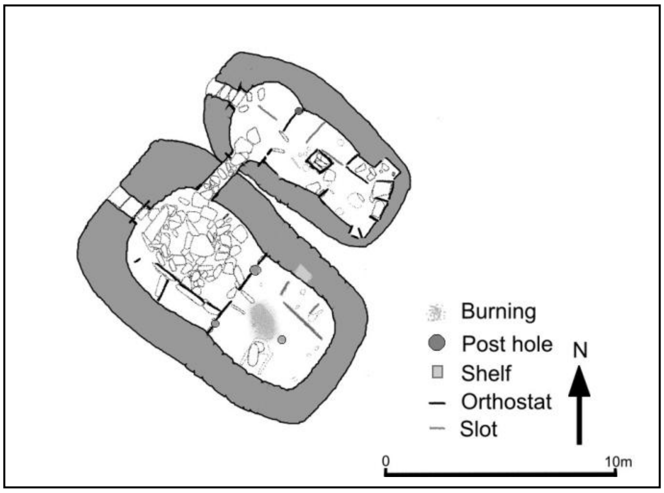
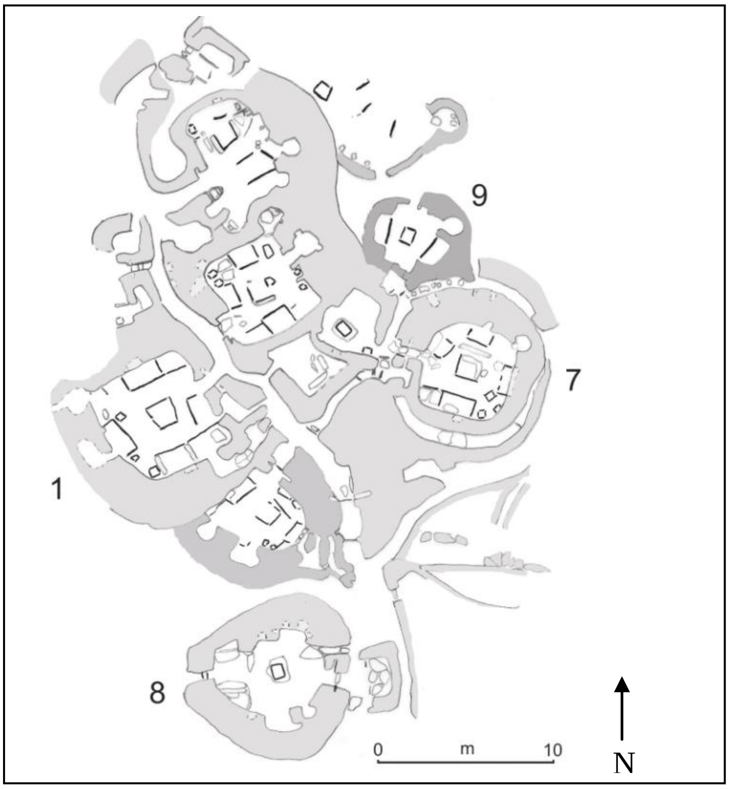


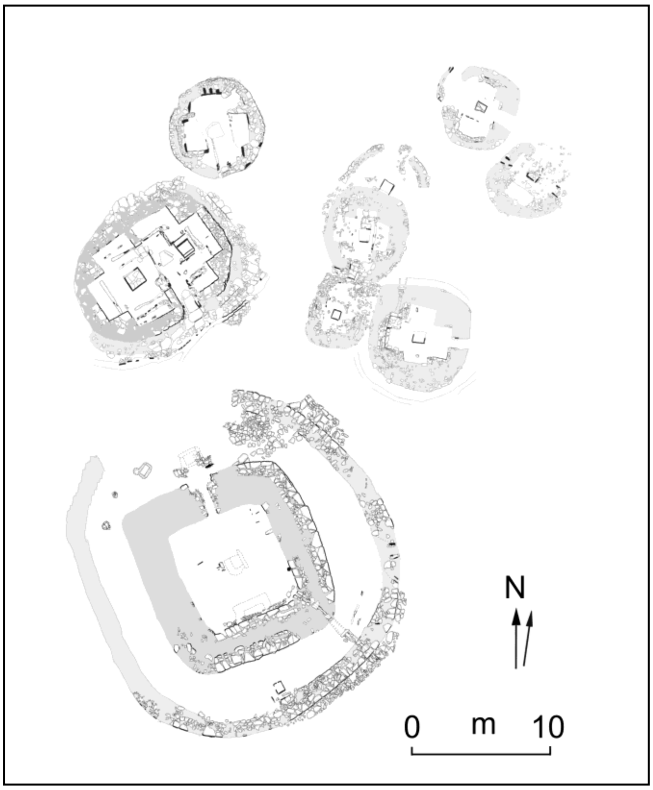
Figure 15. Knap of Howar, an Unstan Ware settlement. Layout of buildings (after Ritchie 1984:47).

Figure 16. Skara Brae, the classic multi-phase Grooved Ware settlement. Simplified layout of buildings: numbers indicate identification of particular structures (after Childe 1931).



Barnhouse shows a greater variety of architectural forms in the Grooved Ware tradition (Richards 2005). One exceptionally large structure with an encircling wall is unique and was interpreted as monumental (bottom left in Figure 17).

Figure 17. Barnhouse Grooved Ware settlement (after Richards 2005. NB. North was poorly defined, as indicated by the two arrows.)



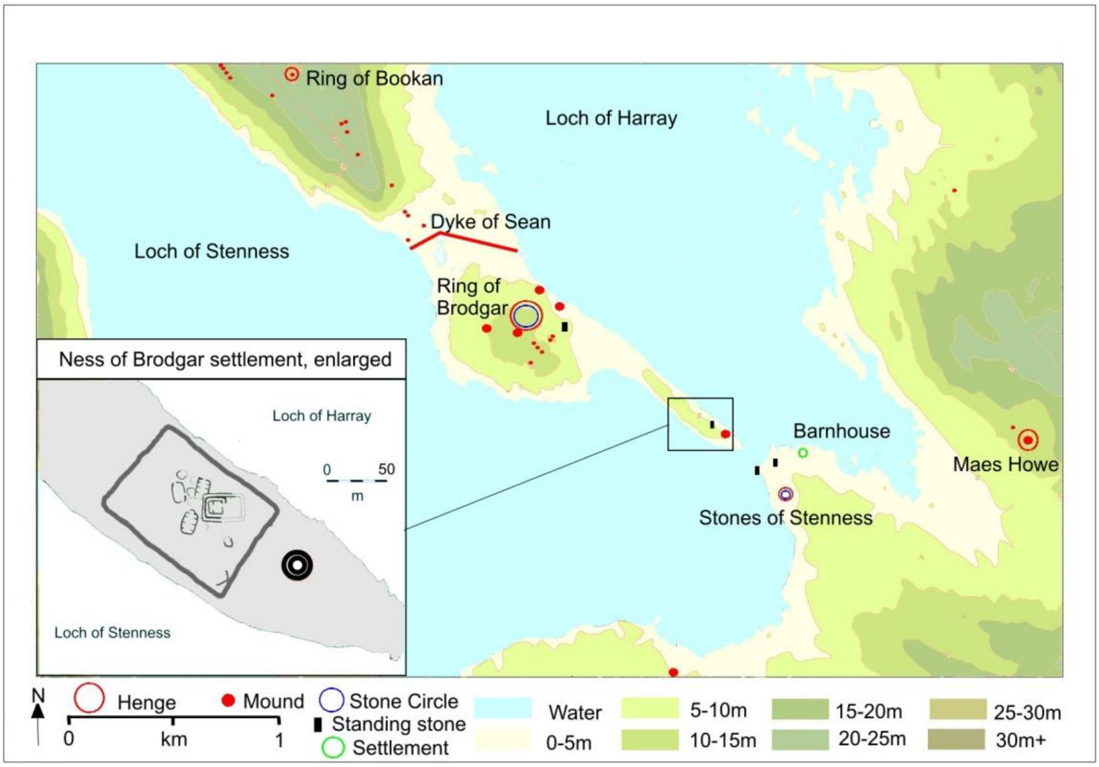


Figure 18. The Ness of Brodgar settlement and surroundings.

The Ness of Brodgar (Figure 18) is exceptional. It has huge buildings exhibiting similarities with both recognised architectural traditions and has produced Grooved Ware from its upper layers (Card 2004, 2010; Card and Cluett 2005; Card and Sharman 2006). Its potentially defensive peninsula location is emphasised by a 2m thick stone wall around the settlement (Card 2010). The position, monumental size and form of the settlement, in the midst of Orkney's main prehistoric ceremonial sites rather than obvious agricultural land, suggests the presence of an elite with both religious and secular power: a centralised authority capable of organising large workforces over extended periods.

In all buildings, open hearths will have produced smoke and dust. Low, narrow entrances would have reduced air flow and prevented large animals entering the houses. People will therefore have been exposed to potentially harmful aerosols but may have been less exposed to zoonoses than in nineteenth century Orkney. Building with stone was probably strenuous and may have contributed to musculoskeletal disorders. The apparent defensive nature of Ness of Brodgar suggests awareness of possible organised large-scale violence, even if its intent was display or symbolism. There may have been sexually determined roles that were associated with activities undertaken in particular areas of the home and to bed size (Childe 1931a; Richards 2005:123) but communities have widely been accepted as egalitarian (e.g. Clarke and Maguire 2000).

Excavated settlement sites have produced evidence of agricultural crops and their ruderals, domestic animals and collected foods (Ritchie 1984; Clarke 1976a; Hunter 2007; Dockrill 2007). Exploiting each requires a distinct suite of activities and exposures to health risks. Variations over time or between communities cannot yet be demonstrated (although see Dockrill 2007:381ff) and by default, Neolithic Orkney must be introduced as if it were a uniform entity (see Piggott 1973).

Collection of berries and wild vegetation can only have been seasonal and may have been arduous since exploitation probably required extensive bending and carrying. Collecting inshore marine foods was probably seasonal, as were methods for exploiting nesting birds and their eggs. Hunting may have entailed communal effort: the most accessible prey were probably birds, seals and red deer, though whales might have been exploited. Seal bone is present only in small quantities on Neolithic sites but this could reflect butchery at coastal slaughter sites or use as fuel rather than a lack of exploitation (Clarke and Sharples 1990:78). Deer bone is more common (e.g. Clarke and Sharples 1990:77; Richards 1994) but deer in Orkney may have been managed to prevent hunting to extinction. Deer bone and antler found in Neolithic tombs may support a special significance for this animal (Morris 2005). Fish bone is frequently encountered and probably reflects at least some line fishing from boats (Nicholson 2007:215). As well as the remains of the animals themselves, some of the tools used in hunting and preparation have been identified: arrowheads, scrapers, blades and pottery, though none for fishing.

Domestic animals known from Neolithic Orkney included cattle, sheep, dog and pig (Armour-Chelu 1992; Bond 2007a,b; Clarke and Sharples 1990). Cattle may have had some special significance: cattle crania especially sometimes form unusual deposits (Card 2011; Moore and Wilson 2010). The sizes of entrances at Knap of Howar and Skara Brae suggest that adult pigs, sheep and cattle did not live intimately with humans. No Neolithic pens or byres have been confidently identified. Evidence for exploitation for milk products (Jones *et al.* 2005:289; Serjeantson and Bond 2007b:206) suggests that animals were conveniently accessible. Pigs and dogs have traditionally been fed scraps and waste, which might imply proximity to people. Feeding, especially in winter will most likely have occurred close to stores of fodder (traditionally hay, seaweeds, barley and root vegetables (see Bond 2007b:158)), presumably near settlements. Sheep may have grazed rougher ground than cattle and been allowed to roam, then herded as required but the limited land area of Orkney minimises potential transhumance.

Agriculture is demonstrated in Neolithic Orkney by the presence of grain, tools and ploughmarks (e.g. Dockrill 2007). Barley is the main crop for which evidence has been recovered and there is some evidence for wheat, although this may not have been intentionally cultivated (Bond 2007b,d). Pool and Tofts Ness produced both hulled and naked varieties of barley (Bond 2007b,d). It is likely that ploughing was common as shown by the presence of stone 'ardpoints' and linear ploughmarks but the use of traction animals is less well proven (Rees 1979; Nicholson and Davis 2007:195; Bond 2007a:195-201). Manual cultivation seems certain (Rees 1979; Rees 1986; Clarke 2006). Harvesting grain was probably by sickle but may have involved pulling and grain could have been separated from straw using special tools such as the serrated stone found at Skara Brae (Childe 1930:64); threshing and winnowing are likely but burning of sheaves could have been used to simultaneously de-husk and parch (Graham 1909:173-5). It seems possible that, in Neolithic Orkney, grain was stored among the house rafters, alcoves or beds (potentially explaining the heights of related orthostats), along with other foodstuffs. Although the volume required will have been larger than available in many Grooved Ware associated structures (see below), the form of Unstan Ware associated houses will have facilitated such use - possibly indicated by the large quantity of carbonised grain at Braes of Ha'Breck (Thomas 2007, 2008, 2009, 2010). Although unidentified, special structures could have existed for storage and processing, possibly those interpreted as having ritual associations such as structure 8 at Barnhouse and structures at Stonehall (Richards and Jones 1994, 1995; Richards 2005). Grinding was certainly used as can be seen from the common presence of querns and rude stone tools (Clarke 2006; Rees 1979).

Barley appears to have been a dietary staple, possibly alongside dairy products. Raw grain crops have crude calorific values from about 325kcal to 360kcal per 100g (Ensminger *et al*. 1983:Table F-36; Paul and Southgate 1985:39), depending on maturation (see Briggs 1978:492-515); only 120kcal per 100g boiled (Paul and Southgate 1985:39). Wholegrain hulled barley has 327 kcal (1368kJ) per 100g (Bingham 1987:22). If it is assumed that barley provided most dietary calories, then approximately 600g would be the minimum required daily for a moderately active modern adult male and 450g for a female (i.e. 219kg and 164kg per annum respectively). Four children at 4-year intervals would be expected to need about 4000kcal daily: an additional 446kg barley per annum (following MacCormack 1982). Requirement relates to body weight and activity and may be further increased by factors such as pregnancy, growth and environmental conditions (see Table 3 below). Thus, an individual with a strenuous lifestyle in a cold climate will have greater calorific needs. MSM evidence suggests that Neolithic life was laborious and ethnographic parallels suggest that procreative females might be permanently pregnant or lactating (e.g. MacCormack 1982:1, 7, 9). We might assume the adult requirement to be 300-400kg barley annually for males and 240-320kg for females. Assuming that childhood bodyweights were low but offset by activity and cold, a family of two adults and four children might be expected to need over 1000kg barley each year (ignoring other sources, of which milk products especially may have been significant). In addition to the food requirement, there was a need for seed in the succeeding year, surplus for trade, animal fodder, some allowance for inefficient use and extra for contingencies. Substantial grain storage facilities will have been vital.

Table 3. Individual Daily Calorific Needs: calculated from basal metabolic rates quoted by Bingham (1987:178) and body weights quoted by Hall *et al.* (1989:68ff)							
Age (Years)	BMR	Male Mean wt. W(kg)	Male kcal req = 238BMR	BMR	Female mean wt. W(kg)	female kcal req = 238BMR	Mean calorie requirement
1	0.25W – 0.13	10	564	0.24W – 0.13	9.5	512	538
2	0.25W – 0.13	13	743	0.24W – 0.13	12	655	699
3	0.09W + 2.11	15	862	0.08W +2.03	14	750	806
4	0.09W + 2.11	17	981	0.08W +2.03	16	788	884
5	0.09W + 2.11	19	1100	0.08W +2.03	18	826	963
6	0.09W + 2.11	21	1219	0.08W +2.03	19	845	1032
7	0.09W + 2.11	24	1397	0.08W +2.03	22	902	1150
8	0.09W + 2.11	26	1516	0.08W +2.03	25	959	1238
9	0.09W + 2.11	28	1635	0.08W +2.03	28	1016	1326
10	0.09W + 2.11	32	1873	0.08W +2.03	33	1111	1492
11	0.07W +2.75	36	1290	0.06W +2.90	37	1219	1254
12	0.07W +2.75	40	1357	0.06W +2.90	42	1290	1323
13	0.07W +2.75	45	1440	0.06W +2.90	46	1347	1393
14	0.07W +2.75	51	1540	0.06W +2.90	50	1404	1472
15	0.07W +2.75	56	1623	0.06W +2.90	54	1461	1542
16	0.07W +2.75	62	1723	0.06W +2.90	56	1490	1606
18-30	0.06W+2.9			0.06W+2.04			
30-60	0.05W+3.65			0.03W+3.54			
60+	0.04W+2.46			0.04W+2.76			
			Pregnancy	+0.8-1.2MJ		+250	
			Breastfeeding	+2MJ		+500	
Other considerations			Labourers	2.1x energy			

Barley yields recorded in the Balfour estate records in Shapinsay in the early nineteenth century were between 3:1 and 5:1 (crop:seed), depending on the quality of the land (Barker 2005:34). Seaweed was used as a fertiliser but presumably farmyard manure was also used where available. Yields between 4:1 and 5:1 were recorded in Sanday (Shaw 1980:99), which has an extensive shoreline. Assuming a yield at 4:1 and a family of two adults with four children, a minimum 1350kg of barley must have been harvested, processed and stored annually (about 54 sacks per family). Straw and other foods, equipment and goods will also have required storage.

It is likely that ard cultivation was used to break new ground but was accompanied by hoe, spade and mattock use. Gregg extrapolated from a short experiment to suggest that 31 man-days would be required to hoe and sow 1ha (Gregg 1988:156; Dockrill 2007:390). A requirement of about 5000 man-hours was suggested by the data (i.e. about 62 man-days) but was thought to be excessive because of the experimental conditions). It has been suggested, using these figures, that three adults could have prepared and sown one hectare in as little as 10 8-hour days and that the period could be reduced through longer working days, the use of the beam ard and/or the use of child labour (Dockrill 2007). Harvesting the same area was suggested to require 32 man-hours.

Imposing a model of 61kg seed per hectare, based on figures from Reynolds' Butser Farm experiments and assuming that one hectare would only produce about 15% of a family's calorific needs, *c*7ha would be required per family

(Dockrill 2007). Intensive cultivation may have produced higher yields of as much as 30:1 (Dockrill 2007:391). Such a yield was quoted from the Western Isles and attributed to either a particularly favourable year or intensive cultivation with “liberal quantities of manure” (Shaw 1980:98). This higher yield would provide 70% of a family’s calorific requirements from 1ha (Dockrill 2007:391; but 150% using the figures above). This increased yield figure is based on the testimony of Martin Martin, who visited Harris in about 1695 and recorded hearsay figures of “twenty fold and upwards, and that at that time all the east side of the island produce thirty fold” (Martin 1703:37). Estate records from Orkney may be more reliable because they were based on actual weights sown and harvested but may relate to particular combinations of climate and soil or less intensive manuring. Other yield estimates for the Western Isles have been made: of fivefold or eightfold in some of the more fertile areas but much higher (10:1-15:1) in South Uist (Shaw 1980:98). Modern bere cultivation in Birsay seems to produce a yield of 17:1 (B.Johnson and R.Phillips, Barony Mill, pers. comm.) or 18:1 (Agronomy Institute UHI figures) but the use of fertiliser is said to increase stalk length rather than yield. These figures may be relatively inflated compared with the Neolithic by the efficiency of ground preparation, sowing and harvesting, improved storage, good seed quality and the use of pesticides and herbicides. Nowadays, drainage, marling and machine-ploughing reduce waterlogging, rot and loss, improving germination rates and permitting earlier sowing. The yield estimates for prehistory may therefore have been optimistic and cultivation area and labour/time requirements could have been significantly higher than Dockrill calculated (p77 above).

Grain size from Neolithic contexts was small and this may have been related to environmental factors or early harvesting (Bond 2007b:158). Other evidence suggests that ash, turf, seaweed and animal and human waste were used as fertilisers (Bond 2007b:158ff; Bull *et al*. 1999; Guttman 2001:189ff; Guttman *et al*. 2006). The presence of certain land snail species has suggested and particular weeds shown that intensive gardening was utilised (Evans 2004; Bond 2007b:160ff), creating areas of good fertility and lighter soils, probably relatively easy cultivation. Small-scale intensive cultivation may have been more efficient, giving higher yields than extensive agriculture. Neolithic settlement sites show evidence of economic differences that could relate to land quality and exploitable territory (Dockrill 2007:384).

Barley cultivation must have been a major time and energy requirement. Assuming a 4:1 yield and 7ha cultivation, 70 man-days preparation plus time in collection and distribution of fertilisers would be required in winter and spring for each family. Harvest would require 28 man-days plus time for drying, processing and storage in late summer/autumn. Greater intensity of cultivation might reduce area required but would increase fertilisation requirements. Livestock slaughter would conventionally be expected in late autumn, potentially introducing seasonality of dairying. Wild foods would mostly be available in autumn and seals are highly seasonal in abundance: summer for common seals and late autumn for grey seals (JNCC 2007a,b).

Subsistence activities in Orkney must have been strenuous and highly seasonal. Most foods will have been abundant in late autumn but will have decreased in availability through the following year. Dairying could have been continuous or relied on storage of products such as cheese but the scale and form of such activity has not yet been determined.

1.7 SUMMARY

A number of subsistence and settlement features might be expected to produce skeletal sequelae. Such evidence seems highly under-represented and was sought by this project (summarised in Table 4 below).

Table 4. Hypothesised Environmental or Social Factors with Possible Skeletal Effects in Neolithic Orkney		
Hypothesis	Possible Effect	Osteological Test
Small isolated population with a small gene pool	Inbreeding	Identification of non-metric traits and inherited diseases
Relatively peaceful life due to remote location	Little interpersonal violence	Palaeopathological study
Little exposure to infectious disease in an isolated settlement	Few chronic transmissible pathological conditions	Palaeopathological study
Agriculturally marginal area with risks of crop failure and insufficiency of produce for subsistence	Exploitation of marine foods	Stable light isotope study to test for raised $\delta^{13}C$ and $\delta^{15}N$
Agriculturally marginal area with risks of crop failure and insufficiency of produce for subsistence	Nutritional stress	Stable light isotope study to test for raised $\delta^{15}N$
Agriculturally marginal area with risks of crop failure and insufficiency of produce for subsistence	Nutrient deficiencies	Palaeopathological study
High latitude with cold weather and dark dwellings led to low natural light incidence and avitaminosis D	Rickets or osteomalacia	Palaeopathological study
Smoky or dusty homes; storage of damp hay/straw led to inhalation of aerosols or spores	Pathological lung conditions	Palaeopathological study
Animal management, dung collection and milk processing led to exposure to zoonoses	Possible infection	Palaeopathological study (calcified cyst recovery may have been unlikely)

Exploitation of natural resources led to exposure to risk of falls or other accidental trauma	Fractured bones, infection	Palaeopathological study
Extensive and intensive agriculture required extensive heavy manual labour	Musculoskeletal development	Examine MSM and skeletal robustness, compare with medieval Orcadians
Sex-related social roles existed with each sex having distinct activity patterns	Different skeletal development not simply sexual dimorphism	Compare male and female bones for consistent differences
Communal burial was practised, with all members of society interred in tombs	Tomb assemblage reflects community mortality	Demographic study
Iconic or ritual significance of human bones or symbolism in tomb form existed, leading to sorting or removal of bones in antiquity	Abnormal distribution and numbers	Examine bone numbers and distribution in tomb by age sex and element
The tombs were in use for extended periods and different interment criteria were employed over time	Certain skeletal types have particular date distributions	Radiocarbon determinations compared with osteological data
Any interpersonal violence occurred over a limited period	Diagnostic lesions have a limited date distribution	Radiocarbon determinations compared with osteological data
The Orkney tombs had a long period of human interment	Varied radiocarbon determinations	Radiocarbon determinations
Biological or social thresholds existed that affected access to foods	Age-related differences in stable isotope values	Age-related differences in stable isotope values
Biological or social thresholds existed that affected access to foods	Age-related differences in metabolic diseases	Palaeopathological study

Evidence from settlement and ritual sites is limited and, despite occasional detailed skeletal reports, earlier studies have failed to exploit osteology's potential. The main aim of this project therefore was to focus on the largest single collection of Neolithic human bones - that from Isbister, South Ronaldsay, Orkney - in an attempt to examine Neolithic society from the most intimate and powerful evidence. Other Neolithic human skeletal assemblages in the Orkney Museum collections and those of ORCA and the Marischal Museum were also analysed so that comparisons between sites and periods could be made. The following chapter describes the situation and nature of the main sites from which the remains came, the collections analysed and the manner in which the analyses were undertaken.

2. MATERIALS AND METHODS

"a research into the contents of the sepulchral mounds themselves seems to be the only resource for elucidating this question." Prichard 1841 vol. 3:xix.

This chapter describes the materials and methods used in the study, paying particular attention to the background of research specific to the assemblages.

2.1 South Ronaldsay and Its Chambered Tombs

"*Its old districts ... were so well marked by nature that they can be readily recognised to-day. The cultivated lands lie in a series of shallow but comparatively sheltered cups, of widely varying sizes, separated by moor and rough pasture. The cups were the districts, and in all but one there was at least one chapel or kirk, and sometimes a couple."* (Clouston 1927:201).

Isbister chambered tomb lies on a cliff-top on the west coast of South Ronaldsay, near to its southern tip. The relief of South Ronaldsay divides the landscape into distinct units. Hills rise up to 100m in height with cliffs where these meet the coast. The cliffs are interrupted by limited coastal lowlands with occasional sandy or shingle bays in a generally rocky shore and there are gentle valleys across the island joining the more prominent bays. Isbister tomb is framed against the skyline at the eastern end of the most southerly such valley.

South Ronaldsay is accessible by boat from the Scottish mainland, only 5 miles away, which dominates southward views. The sea nonetheless clearly defines the agricultural and grazing territory readily accessible to the local community. The distribution of chambered cairns in South Ronaldsay (after Fraser 1983) appears to exhibit a coherent pattern of association between land and tomb. Each known chambered cairn is near a distinct tract of low-lying land (Figure 19 below). In the Black Isle, "settlement was located away from the Orkney-Cromarty tombs: around the river valleys and towards the shoreline, areas overlooked by Orkney-Cromarty cairns" (Phillips and Watson 2000:788). Imposing a similar model, it is likely that the Isbister cairn was associated predominantly with a community occupying the low-lying land to its southwest. This could have become an association with a kin-group or social moiety and it is possible that individuals may have had preferences or rights to tombs outside their immediate homeland.

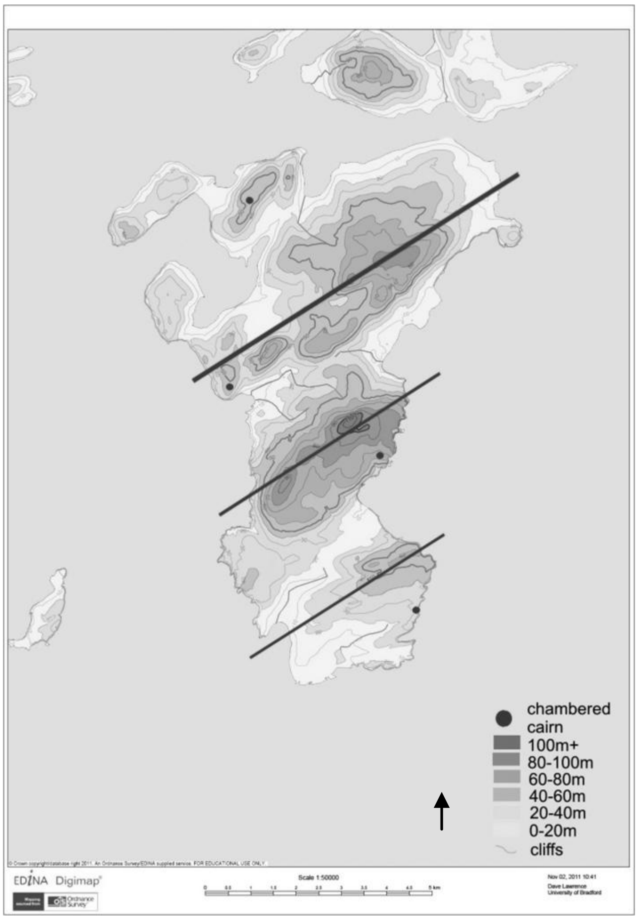


Figure 19. Relief of South Ronaldsay, showing chambered cairn locations.

The straight lines indicate the manner in which the island's relief seems associated with recorded cairn sites.

Tombs, North to South
The Wart, Hoxa Hill (ORK67)
Nev Hill (ORK70)
Hesta Head (ORK63)
Isbister (ORK25)

The problems of assuming association of population with place notwithstanding, the large assemblage of human bone from Isbister (see Table 1, p37 above) presents the rare possibility that a near-complete community is represented for some period. The small numbers of individuals recovered elsewhere means that this cannot be the case at most Neolithic tombs. The relatively simple form of the other South Ronaldsay tombs may indicate increasing centralisation at Isbister with several communities increasingly using and elaborating a single tomb.

This simple view of territoriality was undermined by the 2010 discovery of Banks chambered tomb, only 1 mile from Isbister, on the coast to the south. This seems likely to become highly productive of human remains, having already demonstrated an MNI of 15 from a small part of the deposits. Assuming proportional deposition rates according to area excavated suggests total MNI will be equal to Isbister. The question of the relationship between these two tombs is obviously of great interest but no evidence for this can be invoked, other than architectural distinctions.

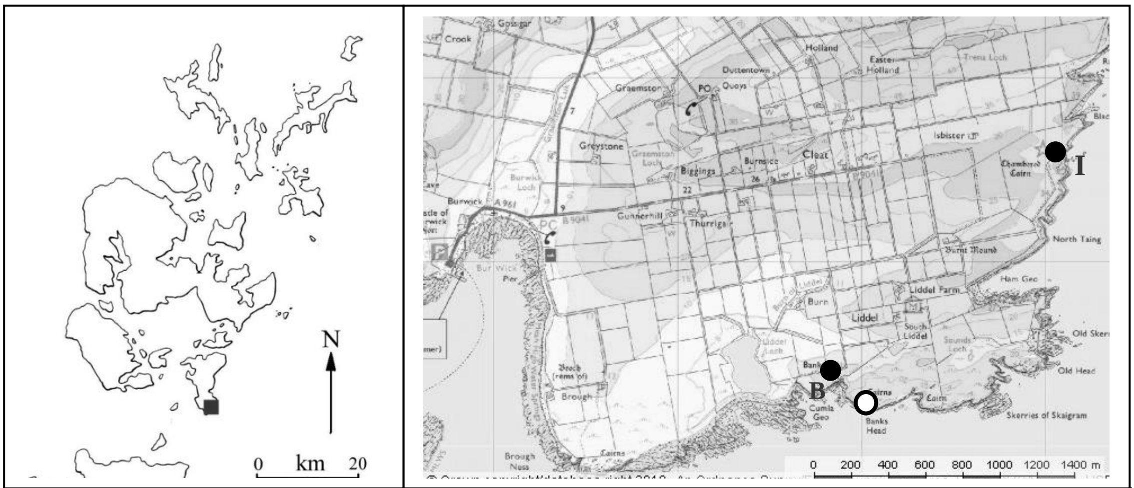


Figure 20. Site locations of Isbister and Banks.

● Chambered Tomb (I = Isbister, B = Banks)

○ Other Burial Mounds (Quarrel Geo / Banks Head)

Both chambered tombs occupy superficially similar locations. They are on relatively high ground, close to a cliff overlooking the sea (Figure 20). Both sites are probably associated with the low-lying area around Liddel Loch. They are divided from other low-lying parts of South Ronaldsay by upland ridges across the island.

There are distinctions between the tombs. Banks has side cells but no orthostat divisions and may be classed as Maes Howe in type. Isbister, despite its side cells is a stalled cairn. Banks is on the southern slope of a shallow valley on the south coast, overlooking Scotland and the Pentland Firth, which may have been a transport route. Isbister lies at the head of the same shallow valley, on the east coast overlooking the open North Sea. Banks is cut into bedrock, Isbister apparently built on the ground surface. Banks' entrance passage faces North, away from the sea to the shallow valley; Isbister's faces to the East, away from the valley but to the sea. This may imply some intentional distinction to reflect different symbolic systems, beliefs or needs (cf Tilley 1994, 2004; Cummings and Whittle 2004).

If the model of Neolithic settlement on low-lying land close to the sea is accepted, then the area of Liddel Loch to the west of Banks Tomb would seem a likely settlement location to serve both tombs. Bathymetry suggests that Neolithic land area will not have been significantly more extensive in this area. What may have changed was the creation of Liddel Loch, which lies behind a storm beach of unknown date (Figure 21 below). In the Neolithic, what is now Liddel Loch may have been land or saltmarsh (cf Echna Loch, Burray

(Wickham-Jones *et al*. 2008)).

Figure 21. The storm beach retaining Liddel Loch, South Ronaldsay.
Taken facing west: Pentland Firth to left, Liddel Loch to right.
Banks tomb lies approximately 400m to the east, Isbister 1600m north-east.

2.2 ISBISTER CHAMBERED TOMB

"…*archaeological sci-fi*." Graham Ritchie 1985

Isbister chambered tomb (the 'Tomb of the Eagles') lies on the island of South Ronaldsay, Orkney at 34705 98449, at an elevation of 28m. (**Map reference:** ND47058449, **NMRS Number:** ND48SE1). The tomb is of particular archaeological significance because of the large volume of human and animal bones that it contained, their high preservational quality and reported evidence for totemism, demography and excarnation (Hedges 1983, 1984, Henshall 1985:102).

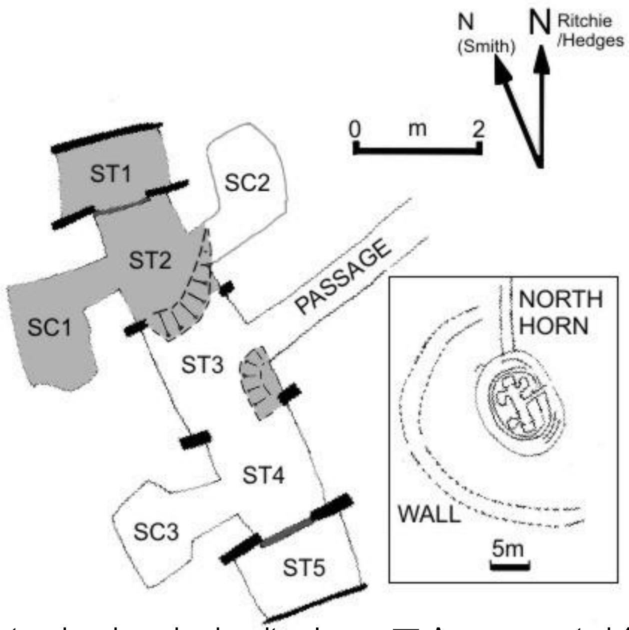


Figure 22. Isbister chambered cairn site plan. ▇ Area excavated 1958.

(Simplified after Hedges 1983; Davidson and Henshall 1989; Smith 1989.)

Excavation History

Isbister chambered cairn was first recorded in 1958. Local farmer Ron Simison, quarrying stone for dry-stone dykes, discovered artefacts at the base of a buried wall-face. His subsequent excavation exposed numerous human bones and demonstrated the presence of distinct chambers within the mound (Ritchie 1961:24). Further human and animal remains (including eagle bones) were recovered from an area excavated “42 ft.” to the north, adjacent to an orthostat that proved to be set in or near a wall (Ritchie 1961:27-8). This is consistent with either the ‘North Horn’ or the ‘revetting wall’ (Hedges 1983:Ill.20). An RCHMS site visit, recording and published report (Ritchie 1961) resulted. The bone was in good condition except where broken during excavation or by sightseers (Ritchie 1961:31). The excavated and exposed bones were retrieved and stored at the University of Edinburgh’s Department of Anatomy. The site was backfilled after blocking SC1 and added to the Schedule of Ancient Monuments.

Mr. Simison resumed excavation at the tomb in 1976, emptying the chambers and recovering a substantial volume of finds, especially human bone (Hedges 1983). No written or drawn records were made at the time but Mr Simison kept separate the finds from the different areas and a small number of photographs were taken (Hedges 1983:1). The North of Scotland Archaeological Services (NoSAS) was later allocated funding to record such excavation as had taken place. Mr. Simison excavated further parts of the monument in 1978 and 1982. The new trenches were recorded in 1980 and 1982 (Hedges 1983:xviii).

In 1987, the site came into the guardianship of Orkney Islands Council and a protective concrete shell was built. A programme of area excavation and consolidation, funded jointly by OIC and HBMC, was undertaken beforehand to record, preserve and improve the appearance of the monument (Smith 1989). A small quantity of bone was recovered and the concentric wall construction of the cairn recorded. Smith recorded the tomb's alignment differently (-22.5^{o}) to Ritchie or Hedges (Ritchie 1961; Hedges 1983; Smith 1989), a discrepancy much greater than accountable by magnetic variation from true north ($-13^{o}16'$ in 1937; $-9^{o}10'$ in 1981). The monument was rescheduled in 1996.

Nowadays, the site is a visitor attraction and the Simison family run the 'Tomb of the Eagles Visitor Centre' at the family farm. In 2008, Mr. Simison was awarded the MBE for his services to archaeology and the tourism industry.

Deposits

The entire site was described with just 16 contexts of limited stratigraphic significance (Hedges 1983:Table 1). The 'layers' described are not discrete contexts but appear to be an interpretative framework omitting 'cuts' and failing to distinguish between different elements of the masonry, or even the blocking stones used in 1958 (Ritchie 1961:25). Hedges noted that the SC2 had been blocked before the major stone fill deposit was laid and although this comment referred to Ritchie's backfill, it does not agree with his description and, whilst confusing, may imply unrecorded modern excavation of SC2 (Hedges 1983:17 but see also Hedges 1983 p22).

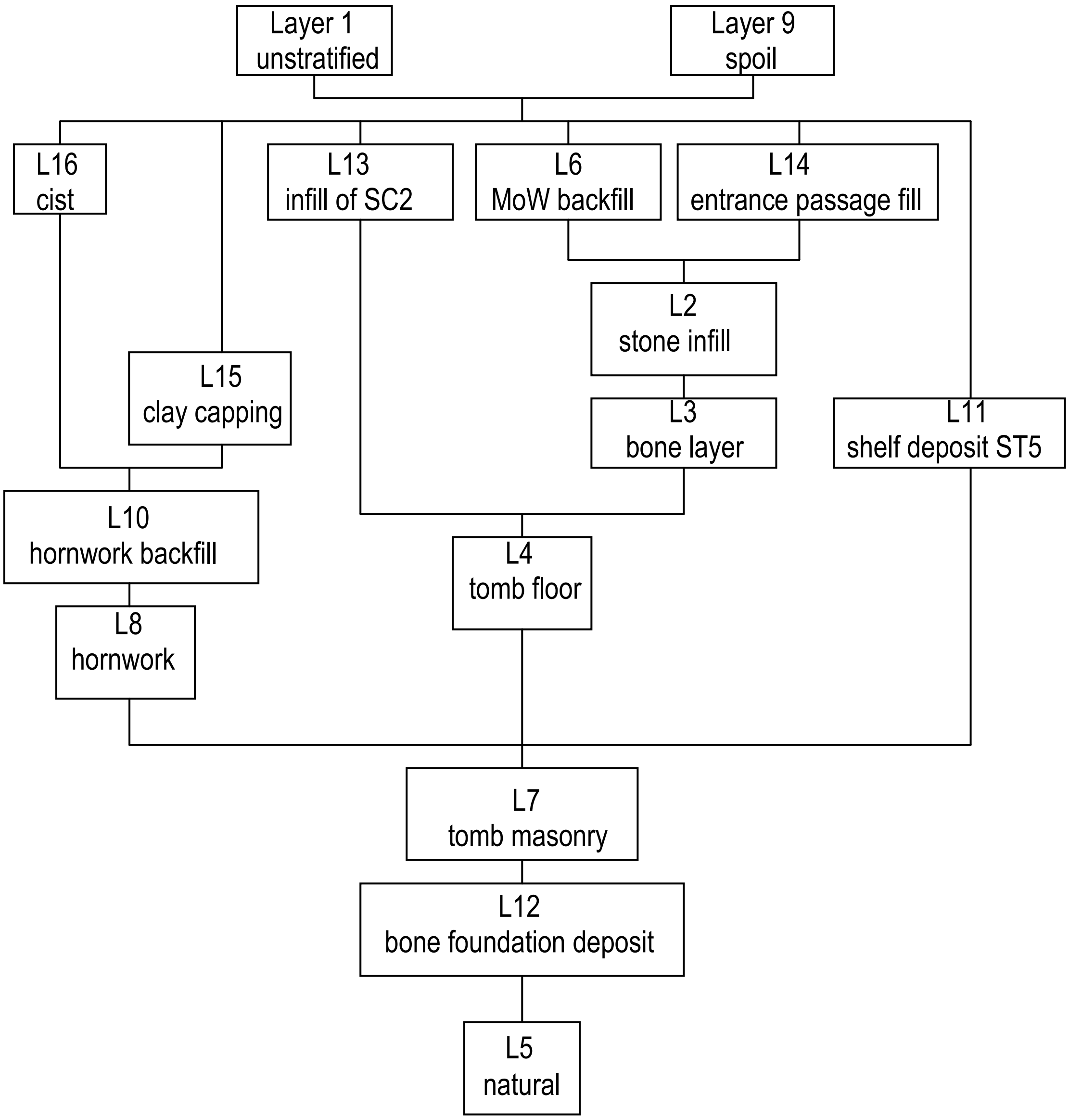


Figure 23. Stratigraphy at Isbister as previously published (after Hedges 1983:31).

The only drawn section of deposits within the tomb (Hedges 1983:22, Ill.19) presents problems. It is more an elevation, with sloping stones obscuring much of the deposit; there was no apparent attempt to distinguish between the layers depicted and interpretation is difficult. This ‘section’ should coincide with an area excavated and backfilled in 1958 (Hedges 1983:Ill.5, facing p6). No such deposit is apparent but this may explain an area of small stones in the drawing about halfway up. This section is depicted in both a colour slide and a black and white print (RCAHMS B9652), and shows that part of the 1976 excavation was a box trench encompassing the southern part of the tomb. Discrepancies between drawing and photographs suggest that the drawing is not a measured record but rather an impressionistic sketch, possibly made later.

It seems likely that the distinction between L12 (a supposed foundation deposit) and L3 (the bone layer) was poorly defined by L7 (tomb masonry). The definition of ‘tomb masonry’ implies a single simple building event, which is not supported by supposed evidence of a stone flag over L12. Attention has been drawn to the apparent anomaly of late radiocarbon dates in the so-called foundation deposit (Sheridan 2005) and the possibility of finds contamination was suggested in the original monograph (Bramwell 1983:159). Stratigraphy was described in the monograph (Hedges 1983:20) but cannot be substantiated: it is entirely possible that the flag overlying the 'foundation deposit' was flooring added later (cf. Sharples 1985a). The distinctions between L16, the ‘cist’ and elements such as L8 (hornwork), L10 (hornwork backfill) and L15 (clay capping) are unclear and it is likely that at least one backfill over the cist and contents was missed. The suggested stratigraphy and phasing of the Isbister deposits cannot be confidently accepted. The monograph has been criticised, especially because “the standard of work and recording was low, and certainly unsuited to a remarkable and productive site,” (Kinnes 1984).

At some time in antiquity, the upper parts of the structure were destroyed, leaving the central chamber and the north-eastern side cell exposed. The chambers were later infilled from above (Ritchie 1961:26, 32). In 1958, the deposits suggested that only the uppermost 9 inches of fill in the main chamber were of rubble, the rest being earthy with human bones throughout, though apparently not in ST1 (Ritchie 1961:26-7, 32). This was interpreted as indicating an earlier incursion that closely matched Simison's initial excavation (Hedges 1983:22-3). Extramural deposits were recognised, including an inhumation. Radiocarbon dating suggested use (and reuse) of the monument from *c*3300BC to *c*2300BC, and *c*1500BC (Renfrew *et al*. 1983).

The Isbister Collection

The Isbister human bone report gives detailed observations and metrical analysis of the bones (Chesterman 1983). Important results from the analysis are spurious, notably demographic, taphonomic and palaeopathological data (or their absence), (Lawrence 2006a,b) and this undermines existing paradigms of Neolithic burial practices (Henshall 2004). The accuracy of osteometry (to ±2mm), however, appears to have been demonstrated (Bernal 2003; Bernal *et al.* 2005:107).

Labelling of Isbister finds in the OM collection has followed several related nomenclatures: year of excavation, context allocated by NoSAS, find location, layer number and a sample number allocated during finds analysis. 'Bone context' codes seem to conflate all these. The codes are not well defined and their use appears to have been idiosyncratic. Some bones retain Chesterman's original markings, which were organised in his notes by bone, side and location. Most bones had only been marked in ink since their return to Orkney. Because the bones had been reorganised previously and become divorced from any original packaging or labels, they are of less certain provenance than might superficially appear to be the case. Some labels are faded or illegible; others suffer from copying errors.

Figure 24. Soil labelled as a bone fragment.

The late Daphne Home Lorimer had begun a review of the human remains (Lorimer 2000), marking them with a new set of identifying ‘DL’ numbers. The labels that now appear are predominantly the result of Lorimer’s attempts to match elements in the collection with descriptions in Chesterman’s original notes (Lorimer 2000). Some labels refer to multiple elements, whilst other elements appear to have been allocated multiple identification numbers. Sometimes inappropriate objects have been included in this process (see Figure 24 above). This numbering scheme has been continued by volunteers allocating numbers in the series, which has compounded the problem of multiple attributions in some cases as illegible labels are replaced.

Definitions of locations within the monument follow Hedges’ nomenclature of stalls and side chambers (Hedges 1983:Ill.4). This leads to an imposition of interpretation that may be inappropriate. In particular, ST1 and ST5 might perhaps best not be considered as ‘stalls’ but rather as something distinct, because they are clearly distinguished from the centre of the monument by their greater breadth and sill stones. (The ‘side chambers’ however had no sill stones.) The ‘shelf’ above both ST1 and ST5 might be a capstone ceiling although chambers could exist above the capstones of the side cells as a result of stress relief architecture. Distinctions between areas cannot be considered absolute because there were no significant physical barriers, whilst each may include distinct parts (e.g. sides and centre).

Table 5. Correlation between Labelling Elements on Human Bones (Hedges 1983).

Excavation Date	‘Layer’ L…	‘Bone Context’ BC…	Location in cairn	Catalogue number. IS…	Description
1958		2a-c	SC1, ST1, ST2	126	Unstratified or disturbed
1976	1	1		129	Unstratified
	2	3a	ST4	119	
		3c	ST4	120	
		4a	ST4	114	
		4	ST4	115	Floor of ST4
		4b	ST4	116	Floor of ST4, Bone bundle
		5	ST3	113	Floor of ST3
		6	ST5	117	Under shelf
	3	8	SC3	118	Floor of SC3
	4		ST3	112	Floor sieve sample
	5				Natural
	6	2a-b	ST1, ST2	127	1958 backfill
	7				Cairn Masonry
	8				Hornwork masonry
	9				1976 Spoil
	10	11a	N hornwork	121	Construction, redeposited natural behind hornwork
		11c	N hornwork	122	Construction, redeposited natural behind hornwork
	11	10	ST5	124	Unstratified / disturbed
	12	7	ST5	111	Foundation of tomb
	13	9	SC2	125	Unstratified / disturbed
	14		Passage		Sand fill
	15				Hornwork capping
	16	11b	‘Cist’	123	N hornwork
		2c	SC1	128	

Finds of different materials may provide insights into tomb use and mortuary behaviour but comparison is confused by the use of distinct series of catalogue numbers for each type (Hedges 1983): [1]-[99] for small finds, [100]-[110] for radiocarbon samples, [111]-[129] for human remains, [130]-[140] for animal bones, [141]-[151] for marine fauna and [152]-[167] for bird bones. The catalogue numbers are neither adequately nor systematically described. They are defined differently in different parts of the text: for example [135], [136] and [137] occupy contiguous columns in the tabulated animal bone result (Hedges 1983:138-9, Table 47) but the descriptive labels differ between successive parts of the table so that [135] may be either 'use' or 'closure' of the tomb, [136] may be either 'closure' or 'horn,' [137] is either 'horn' or 'unstrat.' Because dividers were only used between certain columns, the first interpretation may be most likely but this depends on which parts of the table were misaligned. The use of separate number sequences for different finds inhibits cross-checking for errors.

The 1976 material was initially stored in open containers in a barn. At least one skull was delivered to NoSAS in 1978 having previously been in private hands then given to Birmingham Museum, who passed it to NMAS in 1972 (MS at RCAHMS). The assemblage was damaged through transportation in inappropriate containers (Chesterman 1978; Lorimer 2000). Lorimer's identification project was incomplete and identifications can only be considered best matches with Chesterman's descriptions. These features compound problems arising from poor excavation quality. Two boxes of human bone and several boxes of supposed "non human" and "animal" bones are among the Isbister material curated at NMS. On examination, animal bone boxes were found to contain large quantities of human skeletal material – some 445 human bones or significant fragments in five boxes.

About 1000 animal bone fragments were recovered from Isbister, not including many thousands of fish bones or 725 (identified) bird bones (Barker 1983; Colley 1983; Bramwell 1983). The animal bones were reported as mostly whole (Barker 1983:135). Their manner of deposition is unclear. Small animals, such as frogs, voles, fish, otters and birds could have entered the tomb through faunal activity. Larger animals including sheep and cattle may have entered following partial demolition; faunal behaviour seems unlikely to explain presence of pig or red deer bone however. A predominance of young individuals suggested selection of young animals for some funerary activity but there was no evidence for butchery or slaughter (Barker 1983). Associations of related bones were interpreted as implying the presence of whole animal limbs, despite absence of articulation. Unlike other finds, no animal bone exhibited charring.

Other finds included a large quantity of pottery sherds, predominantly Unstan ware but including two probable grooved ware vessels (Henshall 1983:43). This pottery was recovered from a limited area in the centre of the main chamber, near the entrance passage (i.e. in ST3). Sherds were much affected by burning, in some cases after being broken (Henshall 1983:33). The limited distribution suggests that the pottery was initially deposited in the main chamber opposite the entrance passage. It might be assumed that these either belonged to those interred in the tomb or that they contained some material placed specially.

Evidence of fire above the broken pottery and bone in the central area is intriguing but the absence of records makes it difficult to interpret and it was largely glossed over in the publication.

A group of limpet shells without apices were recovered from a small area in ST5 and were interpreted as a necklace (Henshall 1983:45). If this is correct then it may imply that at least one individual was interred in that area with clothing or that the deposit had special significance.

Bone or antler pins were recovered from sieving of floor deposits in ST3 (Henshall 1983:43). Like the pottery, these are broken and exhibit signs of scorching. A few beads were found, predominantly of bone and mostly in ST3. These might be assumed to have come from personal clothing or accoutrements. The few flints recovered were all of small size and seem unlikely to have been important. It may be that the centre of the tomb was used for initial interment and that is why these finds were found there. Unfortunately, this cannot be tested because the ST3 'floor' was the only part sieved.

Stone artefacts were found deposited against the external superstructure of the tomb in 1958 (Henshall 1983:45-6). These include a jet half-ring, a jet button, three small high quality axe-heads (one of haematite) and a mace-head of exotic stone. Such imported materials presumably had particular significance. The relationship of these items to other deposits is uncertain because they were apparently from a superficial layer.

Table 6. Allocation of Catalogue Numbers for the Isbister Assemblage (Hedges 1983).

Description	Small finds	Radiocarbon samples	Human bones	Animal bones	Marine	Bird bones
1958			126	140 d		166
1958 infill			127			
SC1 1958 infill			128			167
ST1	71					
ST1 1958	68					
ST2 1958	96					
ST1, ST2 backfill	69				145-6	161-2
ST3 'lower fill'	58-67, 70					
ST3 floor	1-46					
Sieving of 'floor' ST3	52-57, 47-50			131	141	
L4 'floor', ST3/4			112-115	132-133	142-3	154-156
ST4 L2 upper fill		108		136		
ST4 'halfway up'		102-3	119		144	159
" to W"			120			160
Pile in L4, ST4			116			
ST5 'top storey'	98 =150		124	138		164
ST5 'under shelf'	51	104-5	117	134		157
L12 Under flags in ST5		100-101	111	130		152-153
SC2 'floor'			125	139		165
SC3 L3				135		
SC3		106-7	118	138		158
Under N horn adj. to tomb	90					
Redep. Adj. N horn	72-88	109	121-2	137	148	163
Cist		110	123		149	
'Scarcement' 1958	89, 91-95					

Note [147] was also catalogued as [70] and [71]; [150] as [98]; and [151] is most of remains listed as [145].

A second group of stone finds was discovered outside the tomb against the 'hornwork.' This consisted of rough stone tools including hammerstones, an ard-point, a ‘club’ and a ‘mattock’ (Henshall 1983:46-7). These are common on Neolithic Orcadian sites and would seem inherently unlikely to have required special deposition but may be related to site preparation and construction.

Previous Work on the Isbister Collection

The Isbister skeletal assemblage was reported to consist of over 15000 commingled fragments from over 342 individuals and affected by taphonomic damage, modern loss and possible removal of elements in antiquity. The Isbister human bone has been studied macroscopically on several occasions (Chesterman 1983; Lorimer 2000). Strontium analysis was attempted (Susan Hughes, Durham University), as have been: trace element analysis (Antoine *et al.* 1988; Pollard *et al.* unpublished), DNA analysis (Miller 1996), cranial trait heritability (Bernal 2003; Bernal *et al*. 2005), facial reconstruction (Maria Vanezis, Glasgow University, 2000) and compound specific stable isotope analysis (Josh Pollard, Bristol University pers. comm.).

There is an extensive secondary literature, both academic and popular, that refers to Isbister. Frances Lee included Isbister in her MA dissertation (Lee 1985) and taphonomic processes have been examined from Chesterman’s records (Smith 2005; Baxter 2001). The Isbister assemblage has particularly been drawn upon to support studies of mortuary practice (e.g. Sharples 1985b:68; Baxter 1999; Reilly 2003). Such studies have sometimes involved misreading, exaggeration or overconfidence (e.g. Sharples 1985b:68). It has been inaccurately claimed that some chambers only held skulls (Sharples 1985b: Figure 7) and that bones were organised into piles, each with a skull on top (Reilly 2003). Claims of structured removal of bones (Richards 1988; Reilly 2003) seem to accept speculation (Gresham 1972; Hedges 1983:218) as observation. Isbister is also very popular with what might be considered ‘fringe’ archaeological interest groups, often much influenced by Hedges’ totemic interpretations and Chesterman’s excarnation theories, whilst tending to be phenomenological or ‘new age’ in nature (e.g. Cope 1998:413; Barthelmess 2004).

Figure 25.

Treatment of the Isbister collection has not always been sensitive. Drilling and sawing have caused excessive damage; gluing has sometimes been inappropriate and often failed, sometimes imitating dysplasias, sometimes of wrong elements. Top left and centre are femora with drill damage; others are examples of gluing together of mismatched elements and failed or inaccurate glued joints. Sadly, this is merely a small selection. See also e.g. Figure174 and Figure 211 below.

Dating of Isbister Chambered Cairn and its Deposits.

Isbister was not fully excavated, so the nature of underlying and incorporated deposits is unknown and *termini post quem* for the structure are absent. Intramural areas of the monument were probably accessible over a long period, so deposits were vulnerable to disturbance and exhibit little stratigraphic evidence. There were also elaboration of the structure, later activity and other disturbance. Isbister is described as a stalled cairn but classification is problematic because the tomb includes elements of both stalled cairn and putative Maes Howe type architecture; vessels of both grooved and Unstan ware were recovered (Henshall 1985:108). This is particularly significant following the discovery of a Maes Howe type tomb at Banks, only 1 mile away. The chronological and social relationship between these two extraordinarily productive monuments is unknown. Conventional models would imply that Banks is later than Isbister (Renfrew 1979:210).

Radiocarbon dates from bone samples have been published for Isbister (Renfrew *et al*. 1983:61). The selection of different anatomical elements for radiocarbon analysis left the possibility that several came from a single individual. IS[104] and [107] were paired femora (*ibid.*:63); IS[103] (and less probably [101]) would be consistent with the same individual. Human bone from ST4, ST5, SC3 and 'below the floor' all returned dates between about 3300 and 3000BC (calibrated). A sample from the backfill returned a date of *c*2650BC and a second sample from ST5 a date of *c*2400BC. IS[110](GU-1187) from an extra-mural deposit returned a date (*c*1500BC) consistent with Bronze Age inhumation.

The bone from “beneath the floor” (IS[100], [101]; GU1178 and GU1179) was interpreted as a ‘foundation deposit’ and assumed to have been deposited either prior to or early in the cairn’s construction (Hedges 1983:262). Since this deposit was accessible to the excavator without demolition of the cairn, access must also have been possible during use of the cairn. It cannot, from structural evidence, be demonstrated as foundational. Bone deposition may therefore have occurred after construction and the radiocarbon assay cannot be used to define a *terminus post quem* for construction. Continued deposition would explain the apparent discrepancy of the radiocarbon date for IS[100] being later than those from other samples (Renfrew *et al.* 1983; Schulting *et al*. 2011). Possible finds contamination (storage in open boxes after excavation, poor early curation: Bramling 1983:159; Lorimer 2000) further reduces confidence in interpreting the radiocarbon dates in relationship with any stratigraphy.

The dating of IS[105] indicates that deposition of human remains continued over a prolonged period (albeit perhaps discontinuously). This date probably also provides the latest properly defined *terminus post quem* for the closure of the cairn, since the area will presumably have become inaccessible after backfilling. IS[109] is intriguing because the calibrated date probability has a rather narrow range but its context, described as ‘infill behind the North hornwork,’ is not informative without better understanding of construction sequences.

Table 7. The Radiocarbon Dating from Isbister (after Renfrew *et al*. 1983).						
Sample	Layer ID	Context Description	Sample Type	C14 date Uncalibrated	C14 date Calibrated BC	δ^{13}C‰
GU 1178 [100]	IS76.72 BC7 L12,ST5	Foundation deposit, immediately prior to building of tomb (?)	Human Bone (R tibia, M)	2295bc (4245bp) ±100 (±140)	2965 ±115 (*3023-2621* **3334-2479**)	-20
GU 1179 [101]	IS76.73 BC7 L12,ST5	Foundation deposit, immediately prior to building of tomb (?)	Human Bone (R tibia, F)	2480bc (4430bp) ±55 (±110)	3215 ±110 (*3327-2926* **3496-2877**)	-20
GU 1180 [102]	IS76.74 BC4a L3,ST4	Deposit on floor of undisturbed Stall 4	Human Bone (L humerus)	2470bc (4420bp) ±90 (±126)	3205 ±110 (*3330-2917* **3510-2702**)	-20
GU 1181 [103]	IS76.75 BC4a L3,ST4	Deposit on floor of undisturbed Stall 4	Human Bone (L humerus, F)	2460bc (4410bp) ±130 (±182)	3190 ±145 (*3356-2891* **3628-2583**)	-20
GU 1182 [104]	IS76.76 BC6 L3,ST5	Deposit under intact shelf, Stall 5 (same sample as Q 3013)	Human Bone (R femur, ?≡[107])	2530bc (4480bp) ±80 (±112)	3285 ±110 (*3351-3024* **3507-2896**)	-20
Q 3013 [104]	IS76.76 BC6 L3,ST5	Deposit under intact shelf, Stall 5 (same sample as GU 1182)	Human Bone (R femur, ?≡[107])	2425bc (4375bp) ±50	3135 ±110	-20
GU 1183 [105]	IS76.77 BC6 L3,ST5	Deposit under intact shelf, Stall 5 (same sample as Q 3014)	Human Bone (L femur, M)	1960bc (3910bp) ±80 (±112)	2470 ±110 (*2567-2207* **2852-2040**)	-20
Q 3014 [105]	IS76.77 BC6 L3,ST5	Deposit under intact shelf, Stall 5 (same sample as GU 1183)	Human Bone (L femur, M)	1880bc (3830bp) ±50	2355 ±110	-20
GU 1184 [106]	IS76.78 BC8 L3, SC3	deposit in undisturbed Side cell 3 (same sample as Q 3015)	Human Bone (L femur, M)	2415bc (4365bp) ±90 (±126)	3120 ±110 (*3327-2885* **3370-2635**)	-20
Q 3015 [106]	IS76.78 BC8 L3, SC3	Deposit in undisturbed Side cell 3 (same sample as GU 1184)	Human Bone (L femur, M)	2310bc (4260bp) ±55	2980 ±110	-21
GU 1185 [107]	IS76.79 BC8 L3,SC3	Deposit in undisturbed Side cell 3 (same sample as Q 3016)	Human Bone (L femur, ?≡[104])	2470bc (4420bp) ±95 (±133)	3205 ±110 (*3331-2916* **3517-2698**)	-20
Q 3016 [107]	IS76.79 BC8 L3,SC3	Deposit in undisturbed Side cell 3 (same sample as GU 1185)	Human Bone (L femur, ?≡[104])	2410bc (4360bp) ±55	3110 ±110	-20
GU 1186 [108]	IS76.80 BC3a L2,ST4	Stone infilling sealing tomb (same sample as Q 3017)	Human Bone (cranium)	2090bc (4040bp) ±100 (±140)	2655 ±115 (*2872-2411* **2913-2151**)	-20
Q 3017 [108]	IS76.80 BC3a L2,ST4	Stone infilling sealing tomb (same sample as GU 1186)	Human Bone (cranium)	2080bc (4030bp) ±50	2640 ±110	-21.2
GU 1190 [109]	IS76.83 BC11a L10	Backfill behind hornwork abutting tomb (same sample as Q 3018)	Deer Bone (mandible)	2310bc (4260bp) ±55 (±110)	2980 ±110 (*3022-2670* **3327-2500**)	-20
Q 3018 [109]	IS76.83 BC11a L10	Backfill behind hornwork abutting tomb (same sample as GU 1190)	Deer Bone (mandible)	2335bc (4285bp) ±45	3010 ±110	-21.5
GU 1187 [110]	IS76.82 BC11b L16	Cist burial inserted in backfill behind North hornwork	Human Bone (R humerus)	1300bc (3250bp) ±55 (±110)	1595 ±110 (*1665-1417* **1871-1268**)	-20
NB It has been suggested that the errors in early radiocarbon determinations should be increased by a factor of 1.4, with a minimum of 110 years (Ashmore *et al*. 2000:45-46): these alterations have been included in brackets after the original published figures, as have new calibrated date ranges (at *68.2%* and **95.4%**) and bp values.						

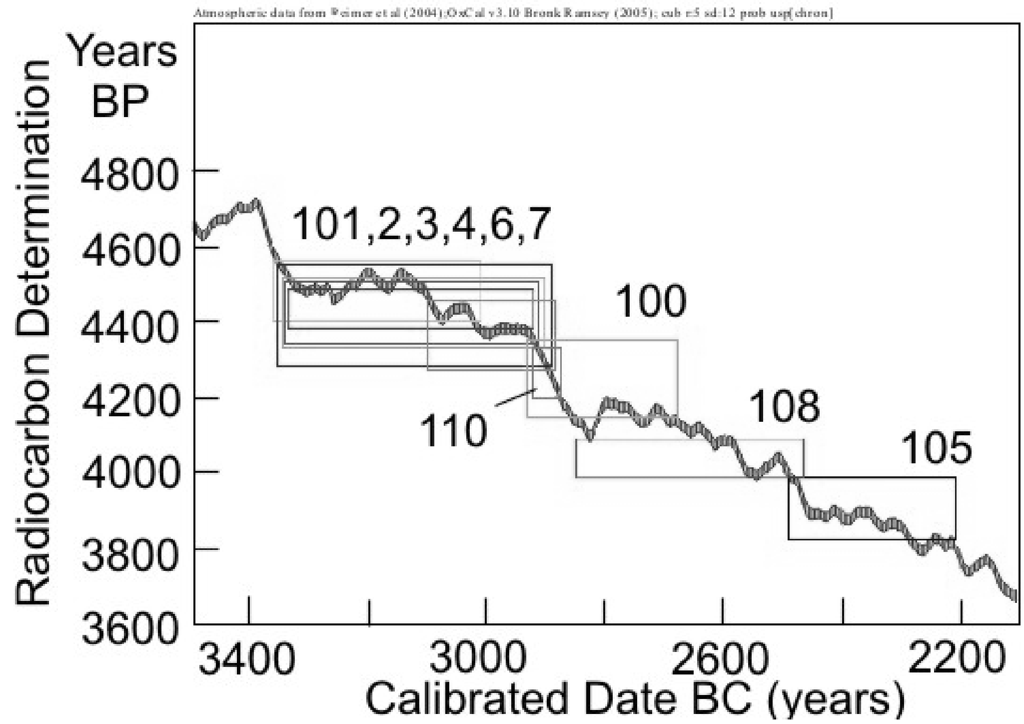


Figure 26. The relationship of Neolithic radiocarbon date determinations (Hedges' samples numbered, at 1sd) from Isbister to the calibration curve, illustrating the significance of plateaux.

The dating evidence in the published monograph is slightly misleading, despite a clear discussion (Renfrew *et al.* 1983:61). 2400BC was considered the date of closure (Hedges 1983:215, 262ff; i.e. *terminus ante quem*) but is properly a *terminus post quem* for the sealing deposits. The interpretation of a 'foundation deposit' led to assumptions of stratigraphic relationships that are uncertain. These were treated as fixed dates and used to define the period of use, introducing error into the demographic analysis (Hedges 1983:262, Hedges 1982).

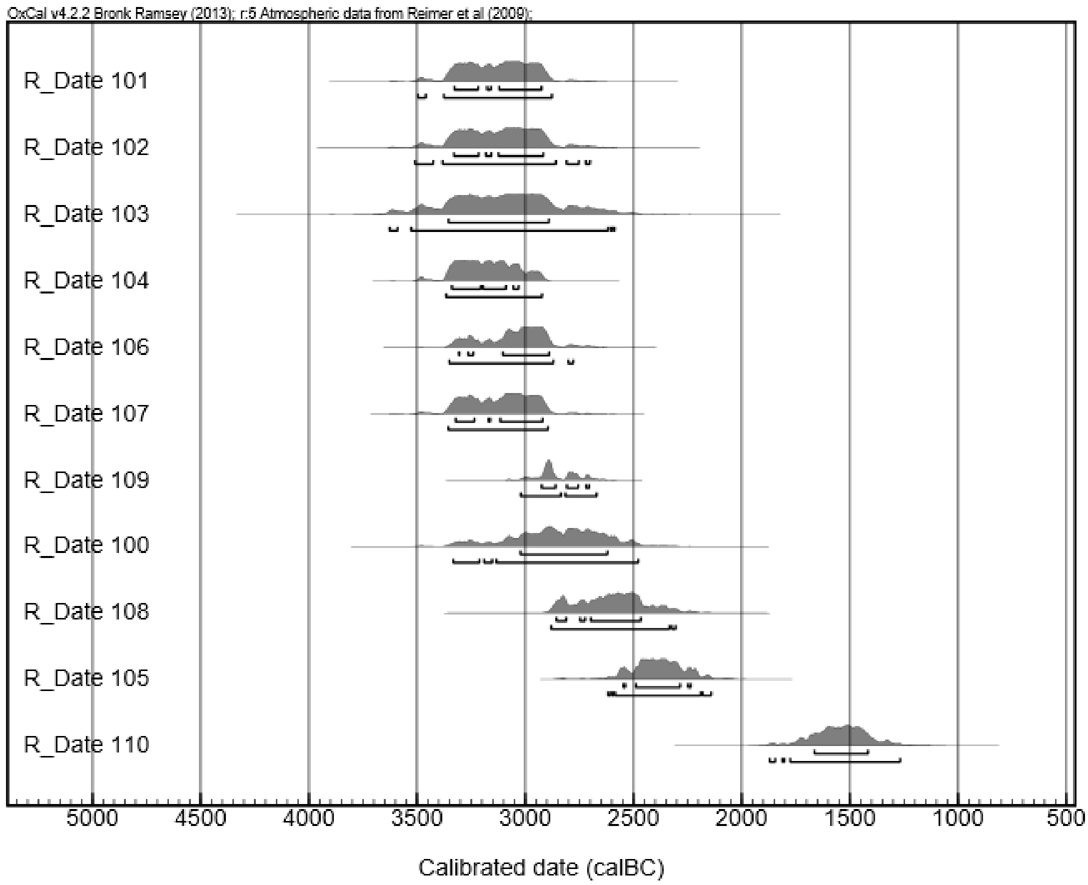


Figure 27. The probability distributions of radiocarbon dates from Isbister (errors increased after Ashmore *et al*. 2000), indicating 68% and 95% probability distributions.

Several dates were closely clustered, which intuitively suggests a major period of use with occasional later deposition. This may be misleading because such interpretation ignores effects from the calibration curve plateau (*circa* 3350-3000BC) and assumes that the dates are independent estimates of a narrow distribution. It has been suggested that non-counting errors also need to be accounted for, with an increased overall error statement for early determinations by a factor of 1.4 and with a minimum error of 110 radiocarbon years (Ashmore *et al*. 2000). This makes little difference to the date ranges from each determination but would even out the probability density through the main area of probability beneath the core of each curve, making peaks less pronounced and reducing the precision of statistical models.

Reanalysis of the original radiocarbon dates from Isbister noted that the replicated analyses from two laboratories were similar and could be satisfactorily combined (although the dates for backfill behind the hornwork appear to have been treated as separate samples within a single phase)(Schulting *et al*. 2010:25-26). This observation was used to justify retention of the original errors for calibration. The dates were then employed in an assemblage formation model in an attempt to refine the dating of such monuments and the chronology of Neolithic pottery using Bayesian statistics (Schulting *et al*. 2011). The assumptions underlying such analyses are critical in producing posterior probability distributions. In this instance, assumptions that combining determinations was valid, that particular samples came from a single phase and that their deposition related to cairn construction have major effects on the results. Of the original determinations, five of six dates were older from the Glasgow laboratory than from Cambridge (Renfrew *et al*. 1983), which implies a systematic element to the differences (cf. Kalin *et al*. 1995). This suggests that it may be improper to treat the replicated assays as independent estimates and that therefore they should not be combined. Combination could also result in inappropriate comparisons with the unreplicated assays, which might be expected to be systematically older than combined values. The influence of the Cambridge determinations shifted combined dates late, off the radiocarbon calibration plateau. The modelled probability distribution was also affected by a narrowly defined radiocarbon determination for IS[106], placed in phase 1 with a calculated combined date of 4289±47bp (Schulting *et al*. 2011:Illus.17). This eliminated the significant early part of the probability density for the other samples assigned to the phase and inferred a relatively tight date range for the main use phase (starting 3130-2920BC and ending 2950-2760BC, each with 95.4% probability)(Schulting *et al*. 2011:25ff).

An alternative model could be imposed without combining dates, that posits IS[106] as a distinct event or part of a second phase and this places the early probability density well into the late fourth millennium BC. A threshold at the end of the calibration curve plateau, which is straddled by the Cambridge/Glasgow determinations, may be included or excluded through date combination. Date distributions for an early phase peak in the late fourth millennium but retain significant earlier probability; the second phase however may reflect continuity.

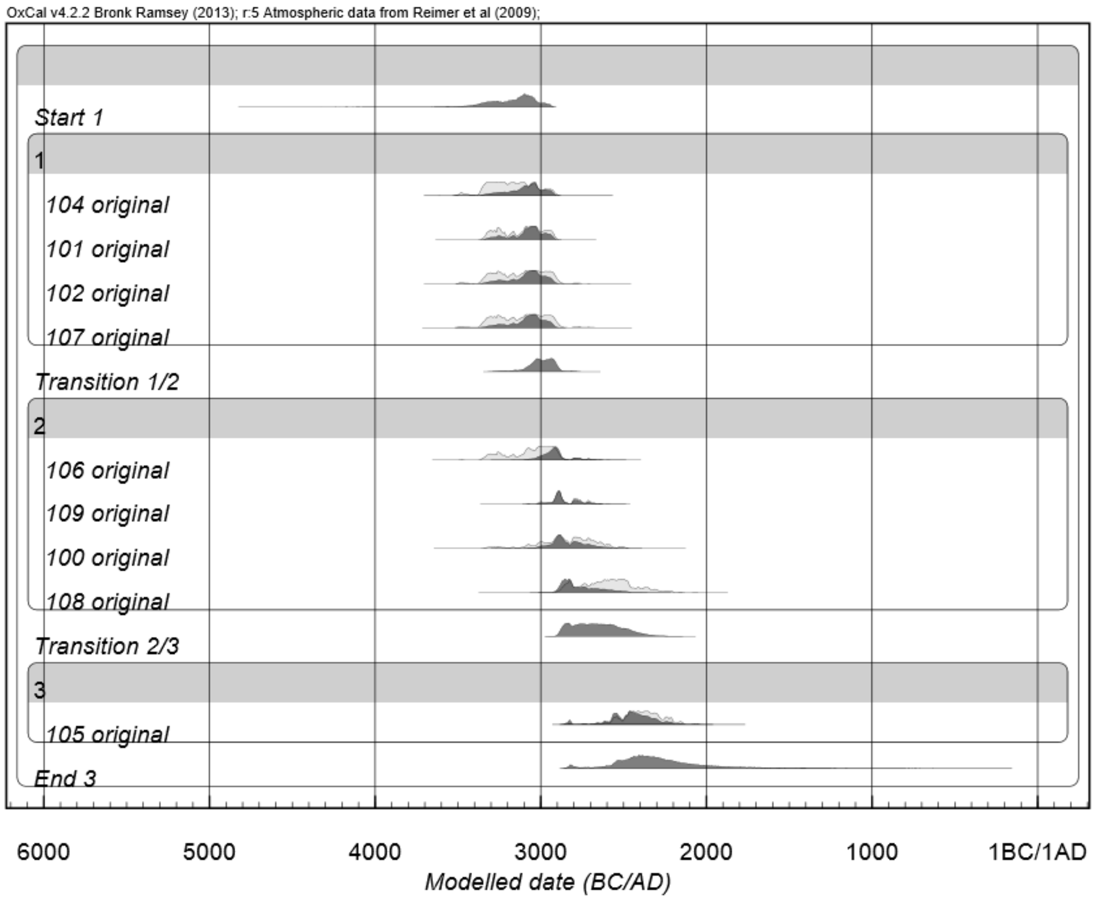


Figure 28. A three-phase model of probability density for Isbister dates based on the original determinations and errors, without combining Cambridge with Glasgow results but assigning IS[106] to the second phase (compare with dating from the model in Schulting *et al*. 2011).

There are implications that should be acknowledged in the translation of explicit probability statements into prose archaeological descriptions: the 'start' and 'end' for example are properly probabilistic *termini post* or *ante quem* but only under the conditional assumptions (especially sample relationships, boundaries and probability distribution forms (e.g. Bronk Ramsey 2009)) used in creating the model; and 'phase' implies a uniformity that may not exist. Most of the early dates are indistinguishable because of the calibration curve plateau but could equally be distinct or identical. There is no robust additional information that could usefully constrain Bayesian dating models for Isbister.

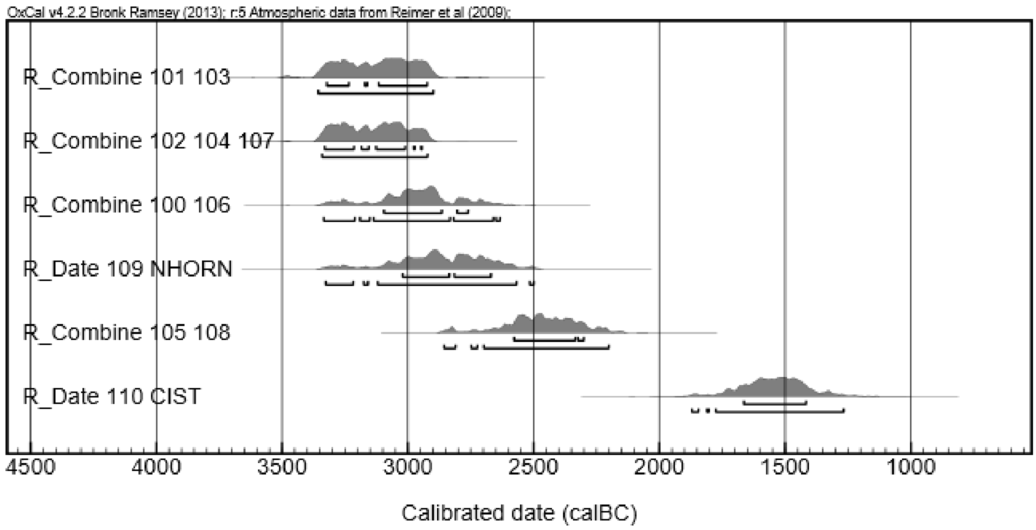


Figure 29. Probability densities from combining potentially related determinations.

An alternative model (Figure 29) may be produced from the assumption that the radiocarbon dating samples were derived from a small number of individuals and that therefore in some cases, the determinations may be independent estimates of dates for a male (right tibia IS[100] and left femur IS[106]), a female (right tibia IS[101] and left humerus [103]), an adult of undetermined sex (left humerus IS[102], left femur IS[104] and right femur IS[107] - thought by

Chesterman to come from the same individual) and another adult (left femur IS[105] and cranium IS[108]). This has little effect on the overall distributions.

Radiocarbon assay of eagle bones from Isbister indicated late third millennium BC dates (Sheridan 2005). It is significant that these dates show that the eagles were probably living after all except possibly the latest of the dated human bones from within the tomb, which undermines support for their supposed totemic significance. It may indicate a period of faunal access to the structure.

Table 8. Radiocarbon Dates from the Isbister Eagle Bones (after Sheridan 2005).

Sample	**Lab. No.**	**Date BP**	**$\delta^{13}C$ value**	**Date BC (if 85% marine diet)**	**Date BC (if 75% marine diet)**
BC6 ST5 L3 [157]	UB-6553	4072±39	-15.6±0.2	2273-2141 (**2345-2051**)	2331-2193 (**2409-2132**)
BC7 ST5 L12 [153]	UB-6552	4017±38	-14.1±0.2	2191-2056 (**2272-2007**)	2264-2124 (**2299-2033**)

Dates shown at 60% and 95% (**bold brackets**) probability. NB. Although baseline values for white-tailed sea eagles are undetermined, these $\delta^{13}C$ values probably indicate very high marine protein levels in the diet, so late dates are more likely to be correct.

The eagle dates may provide evidence for the partial demolition of the monument, since an eyrie would explain the numerous small animal and fish bones and extramural eagle bones. Of further interest is the similarity in date of the eagle bones with sample [105] (GU-1183, Q-3014), which was a human femur. This might possibly suggest that the site was opened close to the relatively late inhumation event but the bones may have been part of the backfill. Comparison with other animal bones (see p47 above) seems to imply some widespread phenomenon contributing to potential animal activity although at least some artefacts and special individuals (e.g. the apparently Neolithic dog at Quanterness (Molleson 1981)) are likely to have been intentional and represent other common features (Lenneis 2007:135-6).

Table 9. Radiocarbon Dates from Funerary Mounds near Banks.

SAMPLE	LAB NO	Material	Years BP	δ13C	CAL BC	REF
Quarrel Geo SK3	SUERC 1198	Human bone	3465±45	-19.2	1907-1669	Ashmore 2003:163
Quarrel Geo INF	SUERC 1199	Human bone	3305±35	-20	1681- 1503	Ashmore 2003:163
Quarrel Geo INF	SUERC 1200	Human bone	3215±40	-18	1413- 167	Ashmore 2003:163
Banks Head E17	Ox-A 1283	Animal bone	1000±60			Hedges *et al.* 1988:297-8
D13	OxA 1284	Animal bone	970±60			Hedges *et al.* 1988:297-8
D11	OxA1285	Animal bone	1810±80			Hedges *et al.* 1988:297-8
D9	OxA1286	Shell	1360±60			Hedges *et al.* 1988:297-8
A4	OxA1287	Shell	890±70			Hedges *et al.* 1988:297-8
A2	OxA1288	Animal Bone	2220±70			Hedges *et al.* 1988:297-8

Possible evidence for continuity of burial practice comes from a Bronze Age date at Isbister. Cairns nearby show Bronze Age, Iron Age and Norse use. The density of funeral mounds near the southern South Ronaldsay coast may indicate that the prominent cliff-top location or panoramic visibility across the Pentland Firth attracted such usage but are difficult to interpret because they too were excavated by Mr. Simison, with little recording.

Figure 30. Trench across a Bronze Age cairn at Banks Head.

Hātað heaðomære hlæw gewyrcean	'Bid men of battle build me a tomb
beorhtne æfter bæle æt brimes nosan;	fair after fire, on the foreland by the sea
sē scel tō gemyndum mīnum lēodum	that shall stand as a reminder of me to my people,
hēah hlīfian on Hronesnæsse,	Towering high above Hronesness
Þæt hit sælīðend syððan hātan	So that ocean travellers shall afterwards name it
Bīowulfes biorh, ðā ðe brentingas	Beowulf's barrow, bending in the distance
ofer flōda genipu feorran drīfað.	Their masted ships through the mists upon the sea.'

Beowulf lines 2802-2808 (Klaeber 1950:105; trans. Alexander 1973:139-40).

2.3 BANKS CHAMBERED TOMB

"*Orkney also has an unfortunate record of non-resourced and wholly unscientific excavation by landowners, with some finds never having made it into the public domain, despite the existence of Scotland's strict law of bona vacantia*."

(Brophy and Sheridan 2012:77)

In 2010, a chambered tomb was discovered 1 mile from Isbister, at Banks, South Ronaldsay, Orkney. The holding of Banks (ND457833) lies on the south coast of the island of South Ronaldsay, on a hillcrest with sea cliffs to the South and a shallow valley to the North. The monument survives as a low mound with stone-built revetting walls, passages and chambers built into a hollow cut into it; side cells have ceilings of horizontally set monolithic flags. Side cells, human bone and absence of orthostat divisions define the site as a 'Maes Howe' type chambered tomb. This was partly excavated in 2010 and 2011, by ORCA. A large quantity of well-preserved human and animal bone was recovered but no other significant finds.

This site is consistent with criteria identified for the location of Neolithic chambered tombs in Orkney (Fraser 1983). Isbister is at the eastern end of this valley and the two sites are intervisible. To the east of Banks and near to the cliff edge lie the later barrows excavated by Simison (Ashmore 2003:163; Hedges *et al*. 1988:297-8).

Archaeological remains were discovered during landscaping, which halted only because the machine had difficulty in removing the bedrock that forms the body of the monument (Hamish Mowatt pers. comm.). Their recognition led to trial trenching (Hedges and Constantine 2010). Assessment excavation followed, in October-November 2010 (Lee 2010). The interior of the tomb was found to be flooded and the deposits were waterlogged. The first phase of proposed full excavation took place in March 2011 and it was recognised as an opportunity to apply the full gamut of modern techniques (Lee 2010, 2011b). A small number of bones were also recovered shortly afterwards, during work associated with emplacing a capstone over the western chamber (Dan Lee, ORCA pers. comm.).

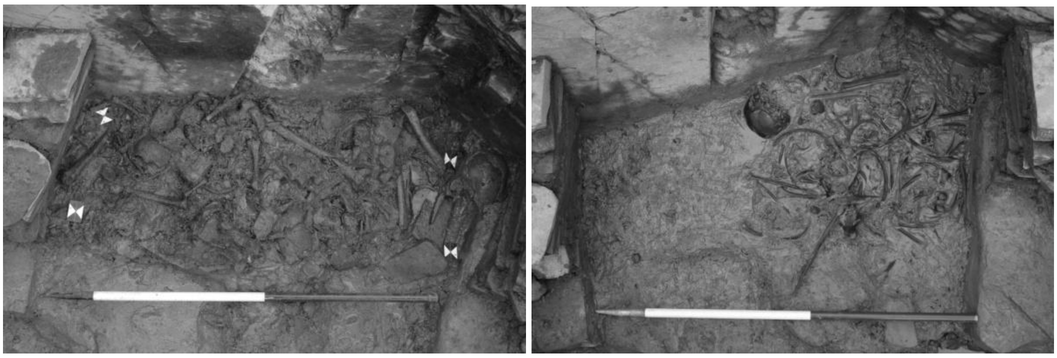


Figure 31. Banks under excavation: western cell (above); passage and centre (below), showing deposits. (Images above courtesy of ORCA.)

The uppermost fill of the central chamber was of clayey soil and rubble. It appeared to have been deposited from above, presumably following removal of the original roof in antiquity. Material had spread laterally into the adjoining side-cells through their entrances and a sloping tip line was particularly clearly evident at the entrance to the northern cell. The side-cells thus had large voids beneath their monolithic capstones. Beneath the late infill was an extensive horizontal layer of stone rubble throughout the tomb, which may have been the result of an earlier, more formal filling episode. There was some indication of a more carefully laid stone blocking deposit between the passage and side cells. Human remains were observed to lie above and between the superficial stones of the stone layer (Lee 2010, 2011b; Lawrence 2012).

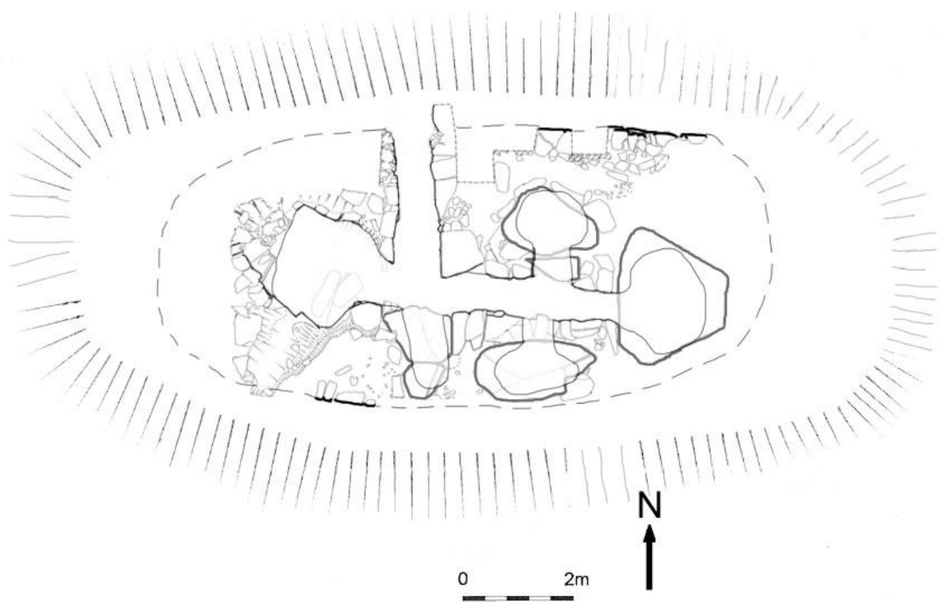


Figure 32. Plan of Banks tomb, showing passage and side cells.

A second phase of excavation, in March 2011, investigated the upper deposits in the central chamber and side cells but concentrated on the complete excavation of the disturbed and flooded western cell. The western cell proved to contain stratified silt and clay deposits that appeared to be intact in some areas, possibly protected by depth and adjacent walling, but more disturbed elsewhere, as evidenced by the identification of deep scoring from a toothed machining shovel. This phase of excavation led to recovery of most of the bone examined from this site.

Figure 33. Banks tomb under excavation in March 2011, taken facing east.

The central foreground shows the disturbed western cell, immediately beyond which the entrance passage extends to the left (north); the monolithic capstones over the other cells are visible and the narrow breadth of the central chamber can be gauged from comparison with the archaeologist standing within (centrally in the picture) on the partly excavated fill. In the background on the horizon to the right later barrows can be seen.

During excavation, each bone or concentration of bones identified was bagged and labelled separately, entered onto a finds index and had its 3-dimensional and stratigraphic location recorded. Many were photographed *in situ* to facilitate the later production of rectified photographic plans and to record condition, bedding and relationships. Each significant volume of soil in the deposits was bulk sampled extensively for sieving and the retrieval of fine bones and small fragments. Soon after excavation, the bones were cleaned and allowed to dry slowly in cool dark conditions to minimise additional damage. Once dry, each find was placed in a separate labelled polythene finds bag. All bones from these excavations were examined by the author.

In early 2012, the site owners commissioned an independent excavation that completely emptied the central chamber and entrance passage. No access to any related finds or records has been provided: only the ORCA finds are discussed here.

1292 catalogue entries were for human bone, all from the most superficial surviving deposits or from the western cell. A small number of bone fragments (124) were scored as unidentifiable and a further 116 only as probably human. A further 216 fragments or bags of small bones were scored as animal. The largest quantity of animal bones was fish, small bird and small animal, and most of these were collected as bags full during bulk sieving. Other animal bones were found individually or mixed in with human bone. The small animal bones were not examined closely, although Orkney vole was identified. Much of this material was probably introduced by faunal rather than human activity.

A small quantity of otter bone was identified, consistent with being the skeleton of a single mature animal. The animal may have used the monument during its life but the bones were not recorded as articulated. This bears similarity with finds at Point of Cott (Halpin 1997:46). Also present is bird bone consistent with a single complete gannet. The bones were not recorded as articulated and the skeleton may have been redeposited or disturbed.

Figure 34. Otter Mandible BSR(909).

Figure 35. Boar Tusk BSR(1302).

There was a single cut pig tusk (Figure 35 above) in the assemblage but no other pig bone was recorded archaeologically. There was a single young red deer frontal fragment and antler fragments consistent with it, indicating an age at death of over 1 year and suggesting that the animal died in autumn or winter. No other deer bone was recovered. Similar finds of tusks and antler are widespread in Neolithic tombs (e.g. Greenwell 1877:33-43, 458-478; Lenneis 2007), suggesting particular significance and possible symbolism of long standing. Boar tusks from some sites appear to have been worked into artefacts or fittings by polishing and drilling for fastenings (e.g. Greenwell 1877:Figure 9) but only a possible cut edge was apparent here (Figure 35, arrow). Juvenile cattle metacarpals and assorted epiphyses were present, possibly from a single individual. Sheep bones from several individuals were identified and all were from young juveniles.

2.4 Other Collections Examined

Whilst the human remains from Isbister form the core of research material, the Banks bones were also included. Other material was also available for this research. The Neolithic human remains from Crantit and Pierowall Quarry; and later assemblages from Lopness, Bustatown, Howe, Buckquoy, Bu of Cairston and Newark Bay in the Orkney Museum collections were sampled. The animal and human remains from Roeberry Barrow were examined. Human remains from the Knowes of Rowiegar, Yarso and Lairo were examined at the Marischal Museum, Aberdeen.

The Marischal Museum holds Neolithic human bones from three Orcadian sites excavated by Grant on Rousay: one adult male cranium and mandible from the Kowe of Lairo (ABDUA14761), three adult male crania and a femur from the Knowe of Yarso (ABDUA14662-6) and 229 bones from the Knowe of Rowiegar (supposedly from at least 17 individuals (Davidson and Henshall 1989:138)). Several crania have been subjected to reconstruction with gluing and filling of missing areas by synthetic material. Poor recovery rates and losses of bone seem likely.

The following sections describe the processes of analysis used to examine the human remains from these sites; further details appear in appropriate chapters.

2.5 Methods

Limitations of the Project

A number of limitations were imposed by the nature of the assemblages:

- The human remains are fragmentary and were commingled at each site.
- Spatial and stratigraphic records were generally poor.
- Recovery efficiency is indeterminable and was probably uneven.
- The collections have previously been subject to sorting, sampling, display, transport, inappropriate storage, handling and possible loss.

It was usually impossible to demonstrate that any two skeletal elements came from a single individual. There was therefore little opportunity for the pattern recognition of skeletal lesions. Assessment of correlation between variables such as age, sex, stature etc. was therefore inhibited. The bones from each site were treated as single populations because this was the only practical approach.

The method employed was essentially divided into two major elements: macroscopic examination and stable light isotope assay of the available materials. Each element of the research is described in a separate chapter along with its results, before being discussed together.

Macroscopic Analysis

The collections of human skeletal remains were examined visually. Each bone was allotted a unique identifying number and full written, sketched and photographic records were made using pro forma record sheets, computer data entry and digital photography. A x1.75 magnifying lamp, microscopes and radiography were employed as appropriate.

Most recording was undertaken at the Orkney Museum storage facilities. The bones were examined methodically in the order that they were encountered. Access to elements of the Isbister assemblage held at the Tomb of the Eagles Visitor Centre (South Ronaldsay, Orkney) and at the National Museums of Scotland (Edinburgh) were arranged separately. Surviving remains from the Knowes of Rowiegar, Yarso and Lairo were examined at the Marischal Museum, Aberdeen. Remains from Ness of Brodgar, Roeberry Barrow and Banks were examined on site and in the author's laboratory.

Individual recording sheets were designed for each bone. Each sheet was picture-led, with outline views of each aspect and each articular surface for annotation. Each observation was both sketched and described, colour-coded with blue for developmental/congenital conditions, red for pathological lesions and black for taphonomic indicators. Each sheet reverse had tables for recording age and sex scores, musculoskeletal markers and headings for prose descriptions of taphonomic and pathological features. Further *pro forma* sheets were designed for recording of taphonomic features (such as colour, erosion and fragmentation) and for developmental features, especially cranial suture obliteration.

Table 10. Comparisons with Zone Codes Defined by Knüsel and Outram (2004).					
Zone ID	Knüsel and Outram Zone Code				
This study	Humerus	Radius	Ulna	Femur	Tibia
1	1	1	A&B	1	1
2	2	2	C	2	2
3	11	5	D	3	3
4	9	6	E	4	4
5	10	7	F	5	7
6	8	8	G	6	8
7	7	9	H	7	9
8	3	10	J	8	10
9	5	4		9	5
10	6	3		10	6
11	4	J		11	

This study	Mandible	Fibula	Shortbones	
1 (or11)	7	1	1	For other elements, the coding was unchanged.
2 (or12)	2	6	3	
3 (or13)	1	5	2	
4 (or14)	6	4		
5 (or15)	3	3		
6 (or16)	4	2		
7 (or17)	5			

The zonation system (Knüsel and Outram 2004) was adapted with a decile coding for the amount of each zone present. An elaborated version was tested, in which the zones were further subdivided but this was excessively cumbersome and abandoned. The fragmentation system was designed for use in comparing human with animal bone (after Dobney and Rielly 1988) but such a study was not intended here so the codes were adapted to progress logically along each bone and facilitate intuitive recording.

Long bones were also recorded in a manner to facilitate assessment of epiphyses, through a presence/absence system, according to area: proximal epiphysis, proximal metaphysis, proximal diaphysis, middle diaphysis, distal diaphysis, distal metaphysis and distal epiphysis. Elaboration of this to include all major epiphyses was felt to obviate the simplicity of the approach without providing sufficient additional information.

Photography was undertaken of all clearly visible pathological features. All crania were photographed to record each cardinal aspect.

All teeth (loose and *in situ*) were recorded individually and assessed for bucco-lingual and mesiodistal crown size (Hillson 1996:70-71) development, calculus (Buikstra and Ubelaker 1994) and attrition stage (Brothwell 1981, Smith 1984). Non-metric variation including cusp pattern was recorded by comparison with the standard casts produced by Arizona State University (Turner *et al*. 1991). Data was input into the database using a socket-by-socket approach to permit observation of prevalences according to location in the dental arcade.

Attempts were made to conjoin fragments from Isbister at OM (cf White 1992: Chapter 4), to find whether disparate features were related and to discover the manner in which fragments had moved in the chambers. This work began with the crania, mandibles and loose teeth. Some survived reasonably complete but very many loose cranial and mandibular fragments were present. The cranial and mandibular fragments were laid out on tables, sorted anatomically and every potential match was tested for fit, taking care to avoid surface abrasion. When conjoining elements were identified, tape was used to temporarily support the rejoined fragments appropriately. The integrity of any identifying information was maintained for each fragment. This process continued until as many fragments as possible had been conjoined. No gluing was done and all tape was removed following analysis.

Following cranial and mandibular reconstruction, attempts were made to match mandibles with crania and loose teeth with sockets. These attempts were almost entirely unsuccessful because of incompleteness, damage, pathology, occlusion of the sockets by mineral deposits and inappropriate gluing of teeth in the past.

Many cranial fragments could not be conjoined but had obviously modern fractures, so it is likely that substantial quantities had been lost during or after excavation. This had not been expected because the spoil heap was reported as having very few bone fragments visible (Smith 1989; Hedges 1983). It is now suspected that some may be in the animal bone assemblage.

Conjoining of Isbister long bones was abandoned following the discoveries that significant quantities of fragments are missing from the collection, and that many of the long bones had been transected during past studies, effectively preventing matches. Osteometric analysis was therefore limited, with consequent problems in calculations of stature and body proportions.

Age Attribution

Age at death was assigned using standard published works, based on the macromorphological features of epiphyseal fusion (Scheuer and Black 2000), suture obliteration (Perizonius 1984; Meindl and Lovejoy 1985; Nawrocki 1998) and the appearance of the pubic symphysis (Brooks and Suchey 1990). Age was assigned to each mandible and cranium using dental eruption for juveniles (AlQahtani *et al*. 2010; Schaefer *et al*. 2009; Ubelaker 1999) and dental attrition for adults (Brothwell 1981). Bone measurements (Maresh 1970; Schaefer *et al*. 2009) were applied to age juvenile bones, where elements were sufficiently complete. Because individual bone fragments were assessed, ageing was often impossible beyond allocation to 'child,' 'juvenile,' 'adolescent,' 'young adult' or 'adult' categories. The presence of pathological features was considered a potentially confounding factor for some methods.

<table>
<tr><td colspan="4">Table 11. Comparison of Ageing Categories</td></tr>
<tr><td></td><td colspan="3">Ageing Categories</td></tr>
<tr><td>Age</td><td>BARC</td><td colspan="2">Other Terms inThis Study</td></tr>
<tr><td>Birth-12 months</td><td>Neonate / Infant</td><td rowspan="3">(Perinate)
Child</td><td rowspan="4">Juvenile</td></tr>
<tr><td>1-6 years</td><td>Early childhood</td></tr>
<tr><td>7-12 years</td><td>Late childhood</td></tr>
<tr><td>13-17 years</td><td>Adolescent</td><td>Adolescent</td></tr>
<tr><td>18-25 years</td><td>Young adult</td><td>Young adult</td><td rowspan="4">(Adult - for purposes of some summary data)</td></tr>
<tr><td>26-35 years</td><td>Young middle adult</td><td rowspan="3">Adult</td></tr>
<tr><td>36-45 years</td><td>Old middle adult</td></tr>
<tr><td>46+ years</td><td>Mature adult</td></tr>
<tr><td colspan="4">NB The most specific attribution was assigned, including age ranges where appropriate. Grouping was by most appropriate term.</td></tr>
</table>

Table 12. Comparison of Scoring Definitions for Cranial Suture Closure			
Score	Perizonius (1984)	Buikstra and Ubelaker (1994)	Nawrocki (1998)
0	Open suture	Open suture	0% closed
1	Closure but suture continuous	Some interruptions	1-50% closed
2	Most open, some interruptions	Significant closure	51-99% closed
3	Mostly closed, some pits	Complete obliteration	100% closed
4	Complete obliteration		

Suture obliteration was scored after Buikstra and Ubelaker for each distinct segment of each major suture, endo- and ectocranially (Buikstra and Ubelaker 1994:32ff, Comas 1960:367ff). Morphology was also assessed (Table 13).

Table 13. Cranial Morphology Scores.	
Occipital bossing / posterior parietal flattening	
1	cranium moderately convex posteriorly
2	reduced convexity
3	cranium almost straight posteriorly
4	concavity superior to lambda caused by jutting of occipital
5	concavity at or superior to lambda with marked jutting of occipital
Post-bregmatic depression	
1	positive ridge along sagittal suture (just assess curve of superior parts, not ridge)
2	Moderate convex curvature of cranium
3	cranium straight superiorly
4	slight concavity
5	marked concavity
Cranial suture profile	
1	major concavity at suture
2	slight concavity or flatness at suture
3	smooth continuous curve of cranium
4	slight convexity at suture
5	major convexity at suture (not from parietal thinning)

Sex Attribution

Standard methods for attributing sex from adult skeletal elements were applied. These are derived from known sex samples in modern collections and vary in expression between groups. There was concern that they might not be directly applicable to a sample from Neolithic Orkney, so a detailed formal assessment procedure was adopted.

Of individual bones, Ossa coxae provide the most accurate sex attribution, followed by crania, mandibles and longbones (Krogman and Iscan 1982:189). The ossa coxae in these collections were almost all too fragmented for sex attribution. Crania survived in better condition and, once reconstructed, were the main source of sex data. In order to make sex attribution as objective as possible, each relevant element was arranged in order according to its expression of one variable, assessing each variable independently. Each indicator was scored according to Buikstra and Ubelaker where appropriate. It was not assumed that the sexes would be equal in number but it was expected that the assemblage would exhibit a range of expression from very male to very female for each variable. Sex attributions were made following consideration of all the recorded scores.

Attempts were made to allocate sex to adult long bones using both metric and morphological criteria, especially the humerus (Rogers 1999; Stewart 1979) and femur (Stewart 1979; Bass 2005). No attempt was made to employ multivariate metric techniques because fragmentation and commingling made this impractical.

Juvenile mandibles were assessed according to form (Schutkowski 1993; Molleson *et al*. 1998; Loth and Henneberg 2001) but codes were altered for consistency. The results were not expected to be reliable (Scheuer 2002).

Table 14. Scoring for Sex Attribution					
Score	1	2	3	4	5
Sex Attribution	Female	Probably Female	Indeterminate	Probably Male	Male

<u>Taphonomy</u>

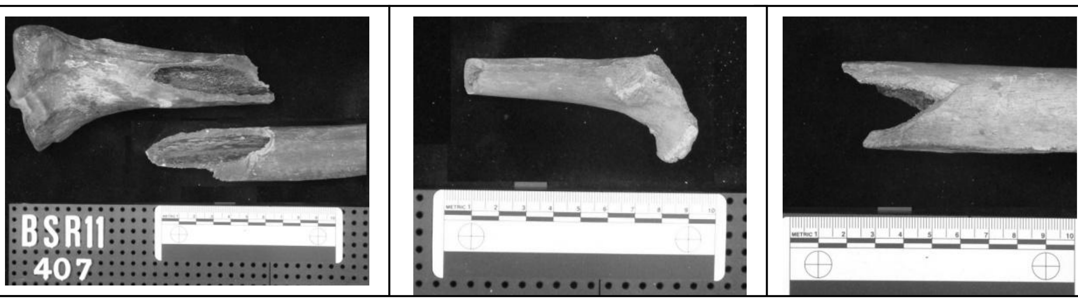
Assessment of the condition of the bones was necessary to permit evaluation of taphonomic processes and the likelihood of particular evidence surviving (cf. Caffell *et al*. 2001). Surface 'weathering' of bone fragments was scored after Behrensmeyer's macromorphological stages, (Behrensmeyer 1978; Buikstra and Ubelaker 1994:98). A parallel scoring system for erosion was also employed (Brickley and McKinley 2004). Splitting and exfoliation were recorded separately.

Standardising colour recording using a Munsell soil colour chart was found to be inefficient because many of the bones were very mottled and many bone surfaces were obscured by superficial coatings. Crania were sketched in colour to record such features but it was impractical to extend this to all elements.

The presence of stains, coatings and concretions required a separate approach. A system based on area obscured was adopted because this permitted assessment of the degree to which features have failed to be observed (Lawrence 2006). Initially, 'stains' and 'concretions' were distinguished between but it became apparent that they are variations along a single spectrum of severity and the two were conflated.

Table 15. Scoring of Surface Stains, Varnishes and Concretions (Lawrence 2006).		
Score	Description	Definition
0	None	No staining
1	Slight	Pale staining or slight concretion might be present but is unlikely to obscure any feature
2	Moderate	Staining or concretion obscures limited parts of the surface but minor features will be clearly visible
3	Heavy	Staining or concretion obscures up to half the surface but major features are likely to be visible in those areas
4	Very heavy	Staining or concretion obscures over half the surface, even major features may be missed
5	Severe	Staining or concretion covers nearly all the surface or all but extremely large features will be obscured.

Scratching, polishing (Shipman 1981:114 Figure 5.7) and abrasion were scored according to severity. Ancient and modern fractures were distinguished by any patination of the fractured surface compared with the rest of the bone. Perimortem fractures were distinguished from breaks in old dry bone through examination of the form of the fracture line and the roughness of the broken surface (e.g. Shipman 1981:104-8 fig 5.2).



a b c

Figure 36. Examples of fracture in antiquity (in bones from Banks).

The patination and colour of the fracture surfaces above are similar to the rest of the bone surfaces. The example on the left (Figure 36a) is similar to a spiral fracture (caused by torsion) but is more likely a jagged transverse fracture (caused by bending), the femur (Figure 36b), has an angled area posteriorly that could possibly be mistaken for a 'butterfly' fracture caused by impact but is probably a transverse fracture, and the other (Figure 36c) is a v-shaped fracture caused by transverse bending stresses. All have slightly rough surfaces, which suggests damage post mortem but not after a great time had elapsed after death. These should be compared with examples of recent fracture (e.g. Figures 47, 49 below), where the fracture surfaces are clean and very pale in comparison with adjacent bone, and the fractures are jagged with very rough surfaces.

<u>Osteometry</u>

Osteometry was undertaken to address issues of body proportions, sex attribution and juvenile age. No attempt was made to address any issue of racial affiliation by such methods since this would be a fallacious attribution to some most similar modern group rather than having any phylogenetic implications (e.g. Howells 1995:101). Standard osteometric measurements were made using vernier callipers (after Buikstra and Ubelaker 1994) and were repeated on separate occasions to assess intraobserver error. The number of available measurements was smaller than the collection size might otherwise imply because of fragmentation. All measurements were made bilaterally, where possible.

3. RESULTS OF MACROSCOPIC STUDY

This section describes the sizes of the main assemblages examined, deducing demographic features and inferring recovery efficiency from Isbister and Banks. This is followed by discussions of osteological data and palaeopathological observations. The first part details numbers of fragments identified.

3.1 Numbers of Identified Fragments:

Crania

Two thousand seven hundred and thirty-seven cranial fragments were recorded from Isbister. These varied in completeness from small identifiable fragments to complete crania. Many were trivial and many could be conjoined, so that two hundred and thirty-seven substantial cranial fragments were recorded, from 85 identifiable crania (Table 16). Large quantities of cranial bone were absent, often from elements that should be readily identifiable and joined across modern breaks. This suggests that losses are modern. No part of the cranium submitted for radiocarbon dating in 1978 (Renfrew et al 1983; Chesterman 1978:vol.1 March1ff (*sic*)) could be identified.

It was found that the scoring for proportion present of each zone was too subjective for accurate use. Examination of the raw records indicated that values 6 and 7 were rarely used whilst values 3 and 4 were overused to a degree that might have indicated hyperostosis if taken at face value.

Table 16. Cranial Fragments Recorded from Isbister.						
	Number Recorded by Completeness					
Zone	**<30%**	**30-50%**	**>50%**	**Fragments**	**Individuals**	**% of Expected**
1 frontal	117	52	57	226	83	98
2 frontal	123	33	57	213	81	95
3 parietal	266	43	53	362	65	76
4 parietal	225	51	54	330	65	76
5 occipital	338	30	47	415	81	95
6 temporal	56	30	68	154	85	100
7 temporal	62	23	75	160	83	98
8 sphenoid	37	8	48	93	45	53
9 sphenoid	34	10	42	86	42	49
10 malar	8	8	51	67	43	51
11 malar	13	7	54	74	46	54
12 maxilla	36	9	68	113	66	78
13 maxilla	31	8	69	108	65	76
14 nasal	16	5	39	60	40	47
15 nasal	16	6	37	59	39	46
NB. Numbers of recorded fragments from Isbister are compared with the number expected based on the MNI of 85 (from cranial zone 6) except where noted otherwise; % figures are rounded to the nearest whole number and insignificant fragments (score<5) are omitted.						

Table 17. Age Distribution of Cranial Fragments Recorded from Isbister.				
	Age group			
Zone	**Juvenile**	**Young Adult**	**Adult**	**Total**
1 frontal	27	14	33	83
2 frontal	25	14	35	81
3 parietal	19	14	30	65
4 parietal	18	14	31	65
5 occipital	22	14	37	81
6 temporal	21	14	46	85
7 temporal	26	13	42	83
8 sphenoid	13	11	18	45
9 sphenoid	11	10	18	42
10 malar	10	13	16	43
11 malar	11	12	19	46
12 maxilla	17	17	30	66
13 maxilla	22	15	28	65
14 nasal	10	12	15	40
15 nasal	10	11	15	39
Note that the totals include those fragments for which no age estimate was made.				

A total of 175 records were made for crania and cranial fragments from Banks.

Table 18. Numbers of Fragments for Cranial Zones from Banks.															
Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
No.	10	11	9	9	5	10	8	5	5	3	2	11	11	4	4
%N	91	100	82	82	46	91	73	46	46	27	18	100	100	36	36
NB. % in the Banks tables refers to proportion relative to the most common zone in that table.															

The relative frequencies of different zones are similar for both sites. This is significant because of the known quality of recovery at Banks. There is a general tendency for under-representation of the nasals (zones 14 and 15), sphenoid (zones 8 and 9) and zygomatic arches (zones 10 and 11). This is probably because of their fragility and protrusion from the cranium, which exposes them to mechanical damage. There is also under-representation of the occipital (zone 5) at Banks, which may relate to its location in the cranium and increased exposure to water leading to increased mechanical damage – if the cranium lay on its base in antiquity. This suggests preferential recovery of large, robust, easily recognised elements but may be biased because of the limited area of Banks excavated.

Mandibles

Table 19. Number of Mandibular Fragments Recorded from Isbister, by Age Group								
Age Group	**Side**	**Number in Zone**						
		1, 11	**2, 12**	**3, 13**	**4, 14**	**5, 15**	**6, 16**	**7, 17**
Juvenile	**L**	4	3	3	3	3	3	2
	R	8	5	6	6	6	5	4
	Both	8	8	8	8	6	8	11
	Total	29	25	26	26	22	25	29
Young Adult	**L**	2	2	0	0	0	0	1
	R	2	2	0	0	0	0	1
	Both	4	4	3	3	3	4	4
	Total	12	12	6	6	6	8	10
Adult	**L**	11	5	8	6	6	9	3
	R	11	8	7	4	12	10	7
	Both	12	13	12	8	6	12	16
	Total	47	40	40	26	32	44	43
Total		**88**	**77**	**72**	**58**	**60**	**77**	**82**
% of Expected 170		52	45	42	34	35	45	48
NB. Differences between totals and sided bone sums occur in the tables because unsided fragments are included. The expected number was based on 85 crania, suggesting 170.								

145 significant mandibular fragments were recorded in the Orkney Museum collections. In many cases these were confidently conjoined. Four mandibular fragments were found in "non human" boxes at the NMS.

Table 20. Numbers of Mandibular Sockets from Isbister.								
	Medial incisor	**Lateral incisor**	**Canine**	**P1 or m1**	**P2 or m2**	**M1**	**M2**	**M3**
Left	79	79	73	73	72	72	72	69
Right	78	80	78	78	81	82	80	71
NB Figures are high compared with mandibular fragments because small fragments were not included in zone counts above: the socket figures are a more accurate measure of presence.								

The number of mandibular fragments from Isbister thereby produced an MNI of 82, consistent with the crania.

Table 21. Recorded Mandible Fragments in each Zone from Banks							
Zone	**1 / 11**	**2 / 12**	**3 / 13**	**4 / 14**	**5 / 15**	**6 / 16**	**7 / 17**
Left	10	10	11	9	8	7	7
Right	8	8	7	6	6	7	6
See table 21 below for % recovery figures							

All mandibular zones from Banks are represented in similar frequencies to the crania, with only slight differences between sides.

Comparison of Banks with Isbister (Table 22 below) suggests minor differences that are best explained by different sample sizes and proportions of the monument excavated. There is an apparent tendency for the posterior (and right side at Banks) parts to be under-represented, which may be due to small sample size and partial excavation. The least recovered parts in each tend to be zones 4/14 and 5/15, probably reflecting relative fragility and identifiability.

Table 22. Comparisons of Recovery from Each Site Based on most Common Element (%).							
Zone	**1 / 11**	**2 / 12**	**3 / 13**	**4 / 14**	**5 / 15**	**6 / 16**	**7 / 17**
IS Left	91	78	76	62	53	80	82
IS Right	100	89	80	64	73	87	96
BSR Left	91	91	100	82	73	64	64
BSR Right	73	73	64	55	55	64	55
NB Different zones were used to identify the apparent number of mandibles at each site.							

Loose and *in situ* Teeth

Table 23. Recorded Find Locations of Loose Teeth from Isbister.									
	SC1	**ST1-SC2**	**SC3**	**ST3**	**ST4**	**ST5**	**CIST**	**NHORN**	**?**
Teeth	35	63	15	71	48	19	3	1	15
NB The origins of these teeth were unrecorded and labelling was poor: some may have been found loose during excavation, others during sieving (e.g. ST3) but it is possible that some were discovered alongside other bones during analysis. This table does not compare like with like for recovery method.									

In total there are 587 teeth in jaws and 270 loose teeth in the Isbister assemblage, which leaves 1076 recorded unremodelled sockets without teeth present (Table 24):

Table 24. Sockets Accounted For (tooth in situ or lost am) from Isbister (teeth / sockets).								
Maxillary	**MED INCISOR**	**LAT INCISOR**	**CANINE**	**P1 or m1**	**P2 or m2**	**M1**	**M2**	**M3**
Left	12/64	5/65	14/65	24/66	38/65	43/61	31/46	28/41
Right	8/63	3/64	14/64	27/65	31/67	48/61	32/48	21/38
Mandibular								
Left	8/79	8/79	11/73	27/73	30/72	47/72	38/72	36/69
Right	9/78	9/80	11/78	30/78	31/81	54/82	37/80	30/71
Sockets	284	288	280	282	285	276	246	209
Filled/closed	37	25	50	108	130	192	138	115
Unaccounted	247	263	230	175	155	84	98	94
% lost	87	91	82	62	54	30	40	45
NB. Not examined for Banks because partial excavation may affect results.								

It is apparent that a large number of teeth are missing from the Isbister collection, especially the anterior dentition. This probably reflects the root form, which makes loss of single rooted teeth more likely.

Vertebrae

Vertebrae from Isbister were generally highly fragmented: 1739 vertebrae (or significant fragments of vertebrae) were identified, 245 cervical, 691 thoracic, 394 lumbar, 155 sacral and one coccygeal; the remainder were unidentifiable. If the Isbister MNI from the crania is accepted as 85, then it is apparent that the recovery of the vertebrae varies according to size and robustness. Fewer than 50% of the expected cervical vertebrae were identified (Table 25), compared with 93% of the expected lumbar vertebrae. The number of juvenile and especially infant fragments was particularly low.

Table 25. Expected and Observed Numbers of Vertebrae from Isbister.

Region	**Expected**	**Observed**	**Proportion recovered**
Cervical	595	245	41%
Thoracic	1020	691	68%
Lumbar	425	394	93%

A total of 177 entries were made for vertebrae or vertebral fragments from Banks, summarised below (Table 26).

Table 26. Recorded Vertebral Fragment Zone Numbers from Banks.

Vertebra	**Expected No. (per person)**	**% Recovered**	**Zone**			
			1	**2**	**3**	**4**
Atlas	1	30	2	4	5	4
Axis	1	12	2	2	1	1
Other Cervical*	5	30	18	25	24	17
Thoracic	12	34	52	61	57	60
Lumbar	5	32	18	23	24	22
Coccygeal	3-5 (some fused)	0	0	0	0	0

* Two fused vertebrae are counted as 2; % recovered is based on MNI 15 (see p208)

Fifteen fragments of sacrum were identified from Banks. Five almost complete sacra and six unfused vertebral bodies were recorded, the remainder being parts of neural arch or ala. Three of the unfused sacral vertebrae are probably the first. There were therefore at least five adults and three different juvenile individuals represented.

Vertebral processes are relatively robust, which is likely to explain why there are more of these than bodies in each category. There may also be some influence from the number of juveniles present, which may have led to reduced survival or reduced collection rate of the vertebral bodies. The numbers consistently suggest that at least five vertebral columns are represented in the Banks assemblage. The low recovery rate compared with Isbister probably reflects the limited excavation area and uneven redeposition density.

Ribs

In total 2190 rib fragments were examined from Isbister, of which 8 ribs were substantially complete and most of the remainder too fragmentary to score as present with a threshold of 50% of the zone. 155 fragments included the sternal rib end and 541 possessed costovertebral facets. If MNI of 85 is assumed, then 2040 ribs should have been present: only 26.5%of the expected proximal ends were recovered and 7.6% of the sternal ends. The number of juvenile and especially infant fragments was disproportionately low.

Table 27. Significant Rib Fragments from Banks.						
	Part					
Ribs	**Proximal epiphysis**	**Proximal metaphysis**	**Proximal diaphysis**	**Middle diaphysis**	**Distal diaphysis**	**Sternal end**
L	17	41	55	70	47	11
R	19	36	47	52	33	6
?	0	6	9	50	20	10
Rib1 L	0	4	5	5	5	1
Rib1 R	2	5	5	6	6	2
Rib2 L	0	1	2	1	1	0
Rib2 R	1	1	2	2	1	0
Rib10+	3	3	3	2	2	2
Total	42	97	128	188	115	32

A total of 234 entries were made for ribs or rib fragments from Banks (Table 27). Numbers of first ribs suggest the presence of six individuals at Banks and this is consistent with the numbers of other rib shafts. The number of left ribs appears to be greater than the number of right ribs consistently but this may be because the right ribs are over-represented in the fragments that could not be sided and imply greater fragmentation of those bones. This may in turn relate to positions of skeletons in antiquity and possibly differing exposure to damage on either side. Comparison with the other bones, the ossa coxae and clavicles in particular, suggests that this difference is not systematic but more likely to be a statistical anomaly. If an MNI of 15 is accepted (pp232ff below) then ribs tended not to be deposited in the one chamber excavated.

Counts of rib fragments are relatively difficult to assess because the diaphysis is prone to fracture into many parts while the sternal end is fragile and tends to be under-represented. The epiphyses of the ribs are clearly under-represented, possibly because of the number of juveniles present, in whom the epiphyses will not have developed or from which unfused epiphyses were not recovered. Recovery rates of rib ends are similar at the sites: about 27% of proximal ends and 8-9% of sternal ends.

Sterna

Very few sternum fragments were recorded from Isbister (Table 28); only a single manubrium and two infant sternebrae from Banks. Those that were identified typically displayed strong markings for *M. pectoralis major*. One had ossified costal cartilage associated with rib 1, usually an indicator of advanced age.

Table 28. Sternum Fragments Recorded from Isbister.

	Zone 1 Manubrium	**Zone 2 Gladiolus**	**Zone 3 Xiphoid process**
Number recorded	21	21	1

These figures are low compared with other elements but this probably reflects the friability of the sternum and its vulnerability to decay in archaeological deposits (see e.g. Waldron 1987).

Scapulae

Table 29. Scapula Fragments Recorded from Isbister.										
	Number of fragments Recorded by Zone									
Side	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**n**
Left	20	23	26	35	29	3	13	4	1	62
Right	21	32	38	37	43	2	14	5	2	63
Total	43	57	67	97	83	6	42	28	9	242
NB totals include unsided fragments; highest possible number of individuals is 62 (zone 4).										

The low numbers of scapula fragments recorded (Table 29) reflect fragmentation of the assemblage and the particular vulnerability of the scapula to damage. Recovery and recognition rates are highest for those zones that have the greatest bone density. Small fragments were identified at NMS but were not significant.

A total of 22 entries were made for scapulae from Banks (Table 30). The numbers reflect robustness of different parts and suggest that at least five or six individuals are represented in the assemblage, which is consistent with the ribs and slightly lower than the numbers of sacra would suggest.

Table 30. Scapula Fragments from Banks									
Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Left	3	5	4	2	5	2	2	2	2
Right	3	4	4	5	6	2	4	3	4
Total	6	9	8	7	11	4	6	5	6

Clavicles

One hundred and six substantial fragments of clavicle were recorded from Isbister, 37 from the right side and 59 from the left (Table 31). This is clearly disproportionate (χ^2=5.4, p<0.025) and Lawrence (2006:90) suggested that this disparity between the sides was due to the left clavicles having greater exposure to trampling. Review of the remains to identify small fragments failed to fully support this hypothesis. When the proportion of each zone was taken into consideration and the number of significant (50%+ of zone present) zones per fragment were examined, the results suggested that right clavicles tended to be less complete (see Table 31). It seems that there is a real disparity in numbers of clavicles from either side, and so the difference in numbers is assumed to be an artefact of assemblage formation: it might possibly reflect loss through removal of right clavicles in antiquity or after sorting for previous analyses but may be due to trampling of <u>right</u> clavicles.

Table 31. Numbers of Each Clavicle Zone Present and Recovery Rate from Isbister by Side *(Italicised figures in brackets refer to zones present at 50%+ of size)*

Side	**Zone 1**	**Zone 2**	**Zone 3**	**n**
Left	21 (25%) *(18)*	43 (51%) *(38)*	37 (44%) *(25)*	59 (*42*)
Right	12 (14%) *(11)*	25 (29%) *(19)*	26 (30%) *(20)*	37 *(26)*
Total	33 (19%) *(29)*	71 (42%) *(59)*	58 (34%) *(47)*	106 *(72)*

NB % figures indicate the proportion relative to an MNI of 85

Table 32. Number of Zones (Scoring 5+) Present Per Clavicle Fragment at Isbister

Number of Zones	Left	Right	All
0	17	11	35
1	17	6	26
2	11	16	28
3	14	4	18

The numbers of clavicles recovered from Banks (Table 33) are consistent with those for other thoracic elements (Tables 26, 27, 30 above), allowing for differences in robustness.

Table 33. Clavicle Fragments Recorded from Banks				
Side	**Zone 1**	**Zone 2**	**Zone 3**	**n**
L	4	7	7	7
R	7	8	8	8
Total	11	15	15	15

Both Isbister and Banks clavicles were underrepresented in the medial epiphysis of both sides, which may reflect taphonomy and a difficulty in identifying very small fragments.

Humeri

Four hundred and twenty-four fragments of humerus were recorded. No surviving parts of the three submitted for radiocarbon dating (Chesterman 1978:vol.1,March1ff) were identified but it is possible that some were present.

Table 34. Number of Humerus Fragments Recorded from Isbister.												
Side	**Zone**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**n**
Left	28	33	48	48	52	56	59	60	20	20	29	124
Right	33	34	48	58	57	59	59	60	19	19	37	117
Total	67	112	102	107	111	117	123	126	49	49	88	424

The number of juvenile and especially infant fragments was disproportionately low. There was however a noticeably disproportionately large number of large proximal fragments from juveniles in the NMS collection, which may imply errors in sorting for previous analyses.

Zones are approximately in proportion with a slightly greater occurrence of left side fragments than right. The relatively low scores for middle diaphysis reflect difficulty in siding isolated fragments. Although the numbers of each side present are unequal, this is not significant (χ^2=0.59, p=0.44).

Table 35. Number of Humerus Fragments Recorded from Banks												
Side	**Zone**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**n**
Left	4	4	7	9	9	10	9	3	3	4	4	11
Right	5	5	5	7	7	7	7	5	4	4	4	12
Total	9	11	17	17	18	17	17	9	7	8	8	33

The recovery pattern from Banks is different: diaphyseal fragments are relatively more common. This is related to an absence of juvenile epiphyses, which will also be observed in other long bones. Another cause is the condition of recovered bones, which are less fragmented from Banks than Isbister, improving identifiability of mid-shaft zones.

Radii

Table 36. Number of Radius Fragments Recorded from Isbister												
Side	**Zone**											**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Left	26	28	48	46	35	25	21	19	44	44	28	92
Right	35	38	41	41	39	19	20	17	40	40	28	90
Total	89	89	89	87	97	48	47	42	84	84	56	256

Recorded zones (Tables 36, 37) are approximately in proportion with a slightly greater occurrence of right side proximal fragments than left at Isbister. Loss of the styloid process (zone 11) occurred in many cases at Isbister but is not an unusual archaeological feature. Relatively low scores for middle diaphysis reflect difficulty in siding isolated fragments, especially compared with the distal epiphysis, which is not apparent at Banks because of lesser fragmentation.

Table 37. Number of Radius Fragments Recorded from Banks												
Side	**Zone**											**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Left	3	3	7	8	8	4	3	4	1	1	1	8
Right	1	1	5	5	5	5	5	5	3	3	2	7
Total	5	5	13	13	13	9	8	9	4	4	3	17

Ulnae

Table 38. Ulna Fragments Recorded from Isbister.										
Side	**Number Recorded with Zone**									**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Left	42	42	51	47	57	9	9	24	24	107
Right	51	51	60	55	61	10	10	26	26	105
Total	93	93	113	102	120	19	19	53	50	300

There is an apparent paucity of diaphyseal zones (Tables 38, 39) that is likely to be because taphonomic factors inhibited confident identification of fragments that actually exist within the assemblage.

Table 39. Sided Adult Ulnae from Isbister.									
Side	**Zone**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Left	39	39	46	43	46	6	6	20	21
Right	48	48	54	49	51	7	8	23	23
Total	87	87	100	92	97	13	14	43	44

Zones are approximately in proportion. The greater number of right side fragments than left is insignificant. The relatively low scores for distal diaphysis reflect difficulty in identifying isolated fragments, especially in contrast with the distal epiphysis. At Banks (Table 40), the distal epiphysis is less recorded, probably because the sample was small and had a high proportion of juveniles.

Table 40. Ulna Fragments Recorded from Banks.										
Side	**Number Recorded with Zone**									**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Left	4	7	7	6	6	6	5	3	0	9
Right	1	8	9	10	8	8	7	2	0	10
Total	5	15	16	17	15	14	12	5	0	21

Table 41. Upper Limb Long Bone Fragments Recorded from Banks, simplified.								
Bone	**Side**	**Prox. ep.**	**Prox. meta.**	**Diaphysis**			**Dist. meta.**	**Dist. ep.**
				Prox.	**Middle**	**Dist.**		
Clavicle (15 entries)	**L**	1	4	4	7	7	5	2
	R	2	7	7	8	8	5	1
	?	0	0	0	0	0	0	0
Humerus (32 entries)	**L**	5	8	8	9	9	9	5
	R	5	9	9	8	8	7	4
	?	4	3	3	3	1	0	0
Radius (17 entries)	**L**	3	5	8	7	4	3	1
	R	1	5	5	5	6	6	3
	?	1	1	1	1	0	0	0
Ulna (21 entries)	**L**	4	7	6	6	5	3	2
	R	3	9	9	9	7	6	2
	?	0	0	3	3	2	0	0

As can be seen clearly in Table 41 (above), long-bone epiphyses are particularly underrepresented relative to diaphyseal metaphyses at Banks, which demonstrates the effect of having a high proportion of juveniles in the sample. It seems likely that the absence of epiphyses was partly due to the limited area of excavation, which will have prevented recovery of loose fragments with a distinct redeposition pattern but possibly also to partial formation of epiphyses.

Carpals

Table 42. Numbers of Carpals Recorded from Isbister.				
Carpal	**Number recorded**			
	Left	**Right**	**Total**	**% of expected 170**
Scaphoid	7	6	14	8
Lunate	6	7	13	8
Triquetral	1	0	1	1
Pisiform	0	0	3	2
Trapezium	2	3	5	3
Trapezoid	0	1	1	1
Capitate	9	8	17	10
Hamate	3	2	5	3

The number of each carpal recovered from Isbister (Table 42 above) appears to be partly related to size and robustness. The numbers from Banks (Table 43 below) are inevitably smaller but are probably also affected by limited excavation. Similarity of proportions of expected numbers recovered at each site may therefore suggest a lower recovery rate at Isbister.

Table 43. Carpals Recorded from Banks.				
Bone	**Left**	**Right**	**Total**	**% of expected 30**
Scaphoid	0	1	2	7
Lunate	1	1	2	7
Triquetral	0	0	1	3
Pisiform	0	0	1	3
Trapezium	0	0	0	0
Trapezoid	0	0	0	0
Capitate	0	0	0	0
Hamate	0	0	0	0
NB numbers recovered may not reflect MNI because of limited excavation				

Metacarpals

Table 44. Metacarpal Fragments Recorded from Isbister.					
Metacarpal	**Side**	**Zone**			**n**
		1	**2**	**3**	
First: MC1	**Left**	20 (24%)	20	21 (25%)	24
	Right	19 (22%)	19	19 (22%)	22
	Total	**39**	**41**	**41**	**45**
Second: MC2	**Left**	30 (35%)	19	27 (32%)	30
	Right	31 (37%)	23	26 (31%)	32
	Total	**61**	**41**	**53**	**62**
Third: MC3	**Left**	31 (37%)	23	31 (37%)	31
	Right	34 (40%)	19	33 (39%)	34
	Total	**65**	**42**	**64**	**65**
Fourth: MC4	**Left**	19 (22%)	18	19 (22%)	22
	Right	17 (20%)	18	16 (19%)	18
	Total	**37**	**36**	**35**	**41**
Fifth: MC5	**Left**	12 (14%)	11	13 (15%)	16
	Right	22 (26%)	19	22 (26%)	23
	Total	**34**	**30**	**35**	**39**
Uncertain: MC?	**Left**	0	2	2	2
	Right	0	2	2	2
	Total	0	47	32	64

Although the overall frequencies of metacarpals (Table 44) reflect bone size and robustness, the number of right fifth metacarpals recorded is slightly greater than for the left side. There is no obvious explanation but it is most likely to be an anomaly of recovery (χ^2=1.25, p=0.26: not significant).

Table 45. Metacarpal Fragments Recorded from Banks.					
Bone	**Side**	**n**	**Zone**		
			1	**2**	**3**
MC1	**L**	3	3	3	3
	R	4	4	4	4
	Total	8	8	8	8
MC2	**L**	2	2	2	2
	R	2	2	2	2
	Total	4	4	4	4
MC3	**L**	0	0	0	0
	R	4	4	4	23
	Total	4	4	4	3
MC4	**L**	1	1	1	1
	R	0	0	0	0
	Total	1	1	1	1
MC5	**L**	0	0	0	0
	R	2	2	2	2
	Total	2	2	2	2
MC?	**Total**	3	3	3	1

There are discrepancies in the numbers of sided metacarpals from Banks (Table 45) but this may be explained through random factors .

Manual Phalanges

Table 46. Numbers of Manual Phalanx Fragments Recorded from Isbister.			
Phalanx	**Zone**		
	1	**2**	**3**
Proximal, first ray	17 (10%)	17	18
Proximal, other	137 (20%)	123	63
Intermediate	47 (7%)	42	47
Distal	5 (0.7%)	5	5
Uncertain	0	10	10

The recovery rate of fragments reflects bone robustness and size. The intermediate and distal manual phalanges were mostly recovered when near complete but the proximal phalanges were often recovered as proximal fragments. The disparity between first ray and other proximal phalanges may reflect misidentification of small first ray fragments.

Table 47. Numbers of Manual Phalanx Fragments Recorded from Banks.			
Phalanx	**Zone**		
	1	**2**	**3**
Proximal, first ray	0	0	0
Proximal, other	12	12	12
Intermediate	4	4	4
Distal	2	2	2

Ossa Coxae

Table 48. Numbers of Os Coxae Fragments Recorded from Isbister.													
Side	**Zone**												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**n**
Left	83	85	41	38	78	70	59	40	45	44	24	21	227
Right	77	76	44	40	70	72	69	35	43	49	35	31	216
Total	164	162	87	78	149	144	136	78	89	96	63	58	481

The numbers reflect significant fragments (>50% present) and not complete bones and it is apparent that the more robust areas have tended to survive in a recognisable condition best. The failure of zone 3 to survive as well as the rest of the acetabulum seems inexplicable.

A total of 67 entries were made for ossa coxae from Banks.

Table 49. Os Coxae Fragments from Banks (Significant Fragments Only).													
Zone	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**n**
L	3	6	3	1	2	5	1	3	2	1	2	0	14
R	9	8	8	6	7	6	8	5	5	6	1	0	24
Total	12	14	11	7	9	11	9	8	7	7	3	0	38

Number of identified fragments reflects robustness of different zones and it should not be assumed from the tables that the iliac crest, for example, was not present at Banks – the zero count above shows rather that it did not survive sufficiently intact to be counted. Discrepancies may relate to the manner in which cadavers were laid out or to circumstances of redeposition. It is likely that apparent asymmetry at Banks will be rectified following further excavation.

Femora

No surviving parts of the four previously submitted for radiocarbon dating (Chesterman 1978, Renfrew *et al*. 1983) could be confidently identified.

Table 50. Number of Significant Femur Fragments Recorded from Isbister.												
Side	**Zone**											**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Left	53	54	65	52	68	62	67	70	70	61	63	222
Right	51	47	57	54	67	60	68	66	70	69	66	210
Total	115	109	132	139	167	144	142	142	144	137	133	642
% of Number Expected												
Left	62	64	76	61	80	73	79	82	82	72	74	
Right	60	55	67	64	79	71	80	78	82	81	78	
Overall	68	64	78	82	98	85	84	84	85	81	78	
NB High diaphyseal representation may be inflated, reflecting multiple entries following fragmentation or robustness. (Totals include unsided fragments)												

The apparent recovery rate seems good for most parts of the femur (Table 50). Underrepresentation of epiphyses may reflect the proportion of juveniles.

Table 51. The Occurrence of each Zone of the Sided Adult Femora at Isbister.											
Side	**Zone**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Left	45	44	45	45	49	34	56	58	61	55	57
Right	47	37	42	49	54	34	51	50	57	56	56
Total	92	81	87	94	103	68	107	108	118	111	113
NB For some fragments, adulthood was based on size and cortical thickness, probably inflating numbers.											

Zones are approximately in proportion with no greater occurrence of one side over the other (Table 51). Relatively low scores for middle diaphysis reflect difficulty in siding isolated fragments.

As with other limb bones, the Banks femora numbers indicate a deficiency of distal epiphyses, which is likely to relate to redeposition of juvenile bones.

Table 52. Number of Significant Femur Fragments Recorded from Banks.												
Side	**Zone**											**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	
Left	9	9	11	9	11	9	10	10	3	3	2	16
Right	11	10	13	5	14	12	12	12	4	4	4	20
Total	20	20	24	14	25	23	23	23	7	8	7	40

<u>Patellae</u>

One hundred patellae were recorded from Isbister, of which 44 were left side and 44 right, the remainder being indeterminate. Overall, 58.8% of the number expected for 85 individuals were identified. The patellae were often almost complete and in good condition. This suggests that the patellae were not vulnerable to erosion or mechanical damage but that those missing were probably simply not recovered.

At Banks, three left and three right patellae were recovered, one of each was juvenile. This is 20% of the MNI and may reflect the limited area of excavation.

Tibiae

One fragment from Isbister was tentatively identified as the remnant of one of the two submitted for radiocarbon dating (IS[100]) (Chesterman 1978; Renfrew *et al*. 1983).

Table 53. Number of Significant Tibia Fragments Recorded from Isbister.											
Side	Zone										**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Left	57	52	54	40	61	59	48	35	24	38	176
Right	50	48	53	43	54	53	45	24	25	35	154
Total	112	101	109	99	129	122	95	61	56	79	581
% of Expected	66	59	64	58	76	72	56	36	33	47	

The numbers for zones 7, 8, 9 and 10 are low (Table 53), probably because many were recorded as 'long bone fragments.' Other zones are approximately in proportion with insignificantly greater occurrence of left side fragments than right. There is one exception, which is zone 4, occurring significantly more commonly on the right side fragments.

Table 54. General Areas Present of Tibiae from Isbister, According to Age Group.					
Adult	**Proximal**		**Middle**	**Distal**	
Side	**Epiphysis**	**Diaphysis**	**Diaphysis**	**Diaphysis**	**Epiphysis**
Left	64	68	44	60	59
Right	63	66	37	53	49
Total	127	134	81	113	108
Sub-Adult					
Left	6	18	15	6	1
Right	5	17	14	5	3
Total	11	35	29	11	4
Note the importance of fusion for recovery of juvenile epiphyses.					

Table 55. Number of Significant Tibia Fragments Recorded from Banks.											
Side	**Zone**										**n**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
Left	7	3	7	6	6	6	3	4	4	5	12
Right	10	3	10	9	9	9	9	9	8	8	12
Total	21	8	21	15	15	16	13	14	15	17	33

As with the upper limb, the proportion of juvenile bones is reflected in the numbers of epiphyseal zones recovered and identified.

<u>Fibulae</u>

Table 56. Numbers of Significant Fibula Fragments Recorded from Isbister.							
Side	**Zone**						**n**
	1	**2**	**3**	**4**	**5**	**6**	
Left	22	45	38	13	9	21	85
Right	20	45	45	13	13	19	87
Total	51	92	84	40	48	55	372
% of Expected	30	54	49	24	28	32	

Relatively low scores for middle diaphysis reflect difficulty in identifying small isolated fragments. There is a slight discrepancy in numbers between the simplified records and those in the zonation system that suggests data entry errors (Tables 56, 57).

Table 57. General Areas Present of Sided Adult Fibulae from Isbister.					
Side	**Proximal**		**Middle**	**Distal**	
	Epiphysis	**Diaphysis**	**Diaphysis**	**Diaphysis**	**Epiphysis**
Left	19	21	18	45	45
Right	20	20	18	49	48
Total	39	41	36	94	93

Table 58. Summary of Lower Limb Long Bones From Banks.								
Bone	**Side**	**Prox. ep.**	**Prox. meta.**	**Diaphysis**			**Dist. meta.**	**Dist. ep.**
				Prox.	**Middle**	**Dist.**		
Femur (47 entries)	**L**	7	9	10	11	9	6	3
	R	6	15	16	14	13	11	4
	?	1	1	0	2	3	2	5
Tibia (36 entries)	**L**	3	9	8	8	5	5	1
	R	4	10	8	8	8	8	3
	?	6	5	1	1	4	4	3
Fibula (22 entries)	**L**	3	4	5	7	9	6	5
	R	2	5	5	5	5	5	3
	?	1	3	3	3	1	1	0

Numbers of lower limb bones from each side at Banks (Table 58) are similar but across elements reflect bone size and robustness, with femora more common than tibiae and fibulae rarest. The only hint of sides being unevenly collected is in juvenile femoral diaphyses. This may indicate idiosyncratic redeposition of juvenile right side bones in the excavated area. The low number of epiphyseal elements reflects the number of juvenile bones.

Tarsals

Table 59. Numbers of Tarsals Recorded from Isbister.				
Tarsal	**Number recorded**			**χ^2 comparing sides, ν=1**
	Left	**Right**	**Total**	
Calcaneus	75 (88%)	68 (80%)	149 (88%)	0.34: p=0.560
Cuboid	34 (40%)	33 (39%)	67 (39%)	0.014: p=0.906
Intermediate Cuneiform	6 (7%)	8 (9%)	14 (8%)	0.28: p=0.597
Lateral cuneiform	16 (19%)	5 (6%)	21 (12%)	5.76: p=0.016
Medial cuneiform	27 (32%)	26 (31%)	53 (31%)	0.018: p=0.893
Navicular	38 (45%)	33 (39%)	74 (44%)	0.35: p=0.554
Talus	77 (91%)	65 (77%)	150 (88%)	1.01: p=0.315

Number of bones recovered bears a direct relationship to bone size, so that the smaller bones are significantly underrepresented in the assemblage. Among the tarsals from Isbister (Table 59 above), the comparative numbers of left and right tarsals appear to be significantly different in four instances (calcaneus, talus, lateral cuneiform and possibly navicular), the left side being more frequent in each case. Only the case of the lateral cuneiform has statistical significance and could not be accounted for by unsided bones but the recovery rate was low and the apparent significance is likely to be illusory.

Table 60. Tarsals Recovered from Banks.				
Bone	**Left**	**Right**	**Total**	**χ^2 comparing sides, ν=1**
Talus	3	9	13	3; p=0.083
Calcaneus	1	4	6	-
Navicular	0	1	1	-
Medial cuneiform	0	0	0	-
Intermediate cuneiform	0	1	1	-
Lateral cuneiform	1	1	2	-
Cuboid	1	1	2	-

The numbers of right side tali and calcanei from Banks (Table 60 above) are greater than left. These are robust, identifiable bones expected to be recovered and the difference could imply that different locality of cadaver elements in antiquity affected redeposition; sample size is small though and this may be insignificant.

Metatarsals

Table 61. Numbers of Metatarsal Fragments Recorded from Isbister.					
Metatarsal	**Side**	**Number Recorded with Zone Present**			
		1	**2**	**3**	**χ^2 comparing sides, ν=1**
First: MT1	**Left** n=39	33 (39%)	33	34 (40%)	0.195: p=0.659
	Right n=43	34 (40%)	37	37 (40%)	
	Total n=95	**68 (40%)**	**81**	**76 (45%)**	
Second: MT2	**Left** n=39	38 (45%)	22	33 (39%)	1.17; p=0.279
	Right n=30	30 (35%)	17	29 (34%)	
	Total n=71	**69 (41%)**	**39**	**63 (37%)**	
Third: MT3	**Left** n=34	33 (39%)	19	27 (32%)	0.057: p=0.811
	Right n=36	36 (42%)	23	34 (40%)	
	Total n=70	**69 (41%)**	**42**	**61 (36%)**	
Fourth: MT4	**Left** n=33	33 (39%)	14	25 (29%)	0.13: p=0.718
	Right n=36	32 (38%)	17	32 (38%)	
	Total n=69	**65 (38%)**	**31**	**57 (34%)**	
Fifth: MT5	**Left** n=32	30 (35%)	16	25 (29%)	0: p=1
	Right n=32	31 (37%)	20	27 (32%)	
	Total n=65	**62 (37%)**	**36**	**53 (31%)**	
Uncertain	**Left** n=4	2	0	2	
	Right n=5	0	4	3	
	Total n=71	7	48	38	

The disparate numbers of metatarsals from Isbister (Table 61 above) are not statistically significant and fail to support the implication from the tarsals that the left side was systematically better recovered.

Table 62. Metatarsals from Banks								
Bone	**Side**	**Prox. ep.**	**Prox. meta.**	**Diaphysis**			**Dist. meta.**	**Dist. ep.**
				Proximal	**Middle**	**Distal**		
MT1	**L**	2	2	2	2	2	2	2
	R	0	0	0	0	0	0	0
	?	0	0	0	0	0	0	0
MT2	**L**	2	2	2	2	2	2	2
	R	4	5	5	5	5	5	3
	?	0	0	0	0	0	0	0
MT3	**L**	1	1	1	1	1	1	1
	R	3	3	3	3	3	3	3
	?	0	0	0	0	0	0	0
MT4	**L**	3	3	3	3	3	2	2
	R	3	3	3	3	3	3	3
	?	0	0	0	0	0	0	0
MT5	**L**	2	3	3	3	3	3	2
	R	3	3	3	3	2	1	0
	?	0	0	0	0	0	0	0
MT?		1	4	8	8	9	7	0

Numbers of metatarsals from Banks (Table 62 above) are low and approximately equal for the different bones; minor variations are probably random.

Pedal Phalanges

Table 63. Numbers of Pedal Phalangeal Fragments Recorded from Isbister.				
Phalanx	**Number with Zone**			**n**
	1	**2**	**3**	
Proximal, first ray	26 (15%)	26	30 (18%)	32
Proximal	40 (6%)	38	40 (6%)	45
Intermediate	6 (1%)	6	7 (1%)	7
Distal	2 (0.3%)	2	2 (0.3%)	4
Uncertain	0	0	1	1

Recovery rate of pedal phalanges from Isbister (Table 63 above) reflects size: it may be noted that two of the distal phalanges were fused to intermediate phalanges, which probably contributed to their prominence.

Table 64. Numbers of Pedal Phalangeal Fragments Recorded from Banks.				
Phalanx	**Number with Zone**			**n**
	1	**2**	**3**	
Proximal, first ray	3	3	3	3
Proximal	3	3	4	4
Intermediate	0	0	0	0
Distal	0	0	0	0
Uncertain	0	0	0	0

Only the larger, proximal row bones of pedal phalanges were recovered from Banks (Table 64 above), which may reflect movement in antiquity but probably relates to the low number overall.

3.2 Nature of the Assemblages

The Isbister collections include disproportionately low numbers of juvenile and especially infant fragments. This reflects recovery and recognition rate as well as deposition in antiquity. Some apparently missing fragments may exist unidentified in the collections due to fragmentation. A rather large number of human bones (445) were discovered in the supposed faunal collection at NMS and it seems likely that more will be with the remainder of the animal bones, especially juvenile and dysplastic bones (which seemed over-represnted in the NMS collection, possibly reflecting increased difficulty of identification).

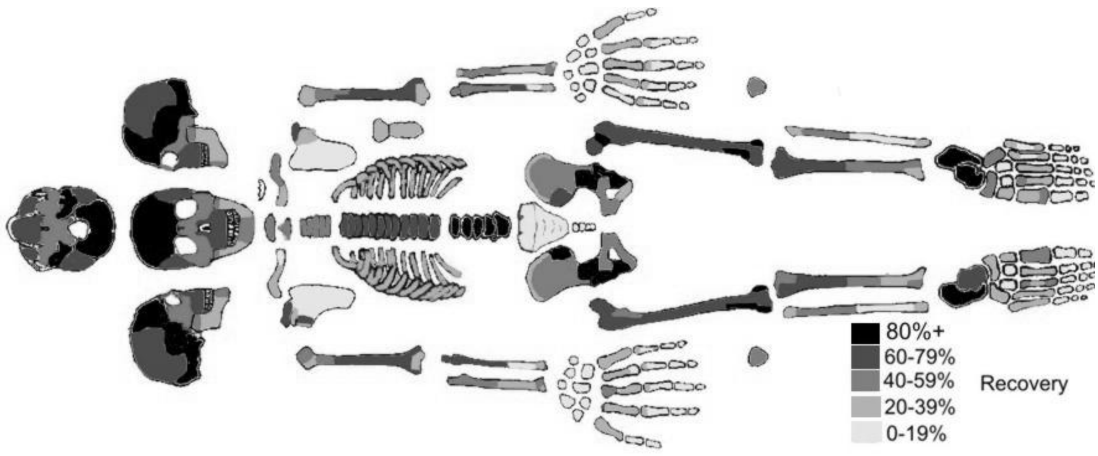


Figure 37. Skeletal representation from Isbister.

There appear to be disproportionate numbers of some elements present, although the expected sample size should reflect random selection. Left side elements appear to outnumber the right side for several bones, notably the tarsals but some upper limb bones have greater right side representation. Few cases have statistical significance and this probably reflects the large number of possible tests rather than intentional selection. It is nonetheless possible that sorting during earlier analyses led to biased losses.

The numbers of each bone type recorded in this project were compared with the numbers recorded in 1978, ascertained through examination of Chesterman's manuscript notes (Chesterman 1978). This was to ensure that results from this study were not biased by later bone losses. It was necessary to work systematically through Chesterman's notes to determine numbers because the published report gives figures for MNI, not bone frequencies. The major limb bones were compared for frequency recorded by side throughout the assemblage because uncertain attribution requires that the collection is treated as a single population. The bones from the NMS animal collection were not included in this study since they would not have been included in Chesterman's catalogue. The results are shown in Figures 38 and 39 below.

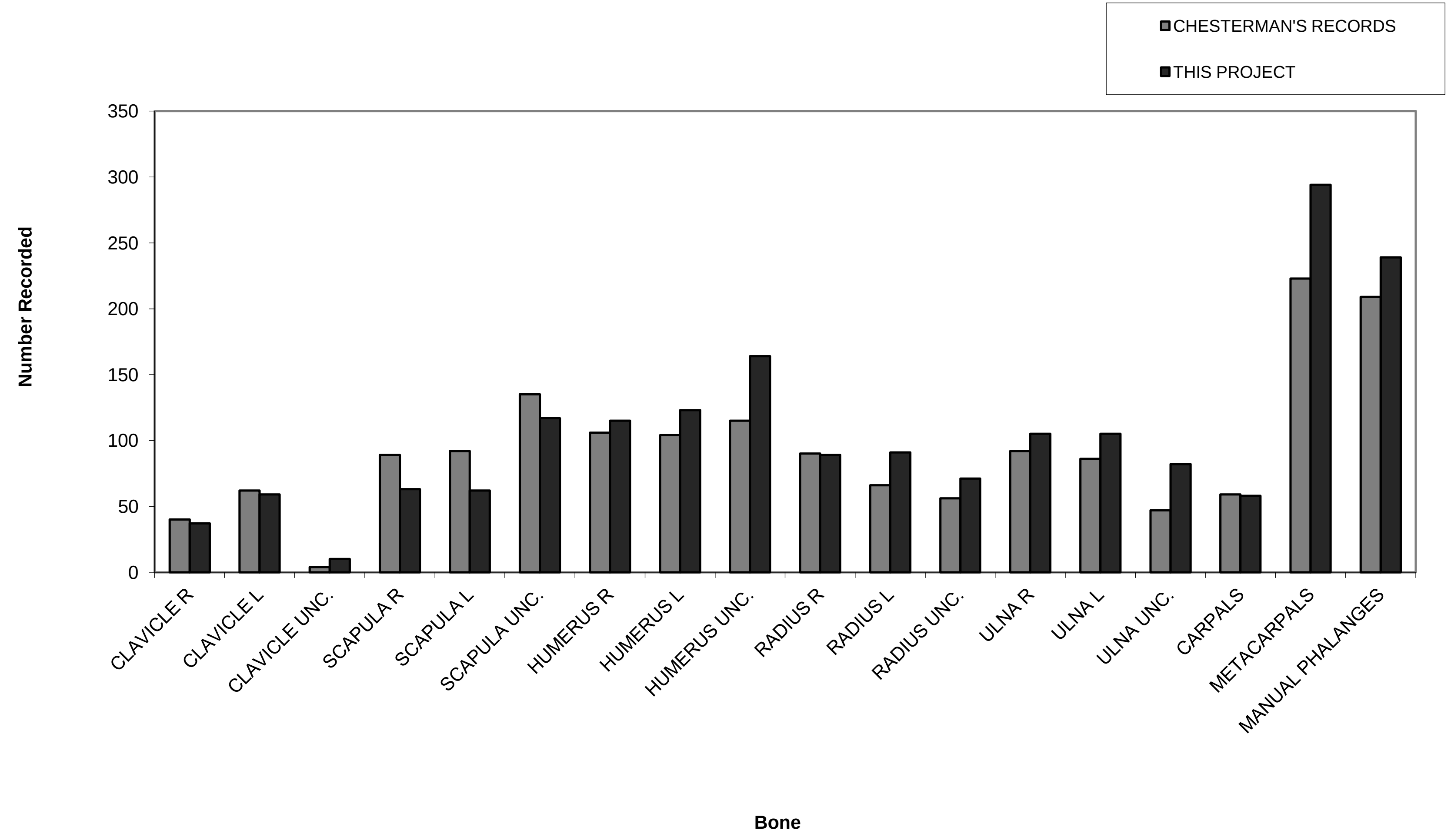


Figure 38. A comparison between upper limb bone numbers recorded previously (Chesterman 1978) and in this project.

Element numbers are sufficiently similar that it can be confidently accepted that there has been no significant loss from the collection since Chesterman's analysis. The discrepancy between left and right clavicles, for example, existed in the original study and is therefore a real artefact of the assemblage. Some discrepancies observed in Chesterman's data, for example the disparity in numbers of the radius of either side, were not repeated here and this is probably due to interobserver error.

Further discrepancies between the results of the two studies require explanation. The number of femoral fragments recorded by Chesterman was lower than was recorded here because Chesterman recorded matching parts together, producing lower totals. The number of tibial fragments conversely was greater in Chesterman's study because many will have been recorded here as 'long bone fragments'. Greater numbers of metacarpals, metatarsals and phalanges were recorded in this project than by Chesterman: some came from bags labelled 'unsorted,' and were presumably not identified in the original study.

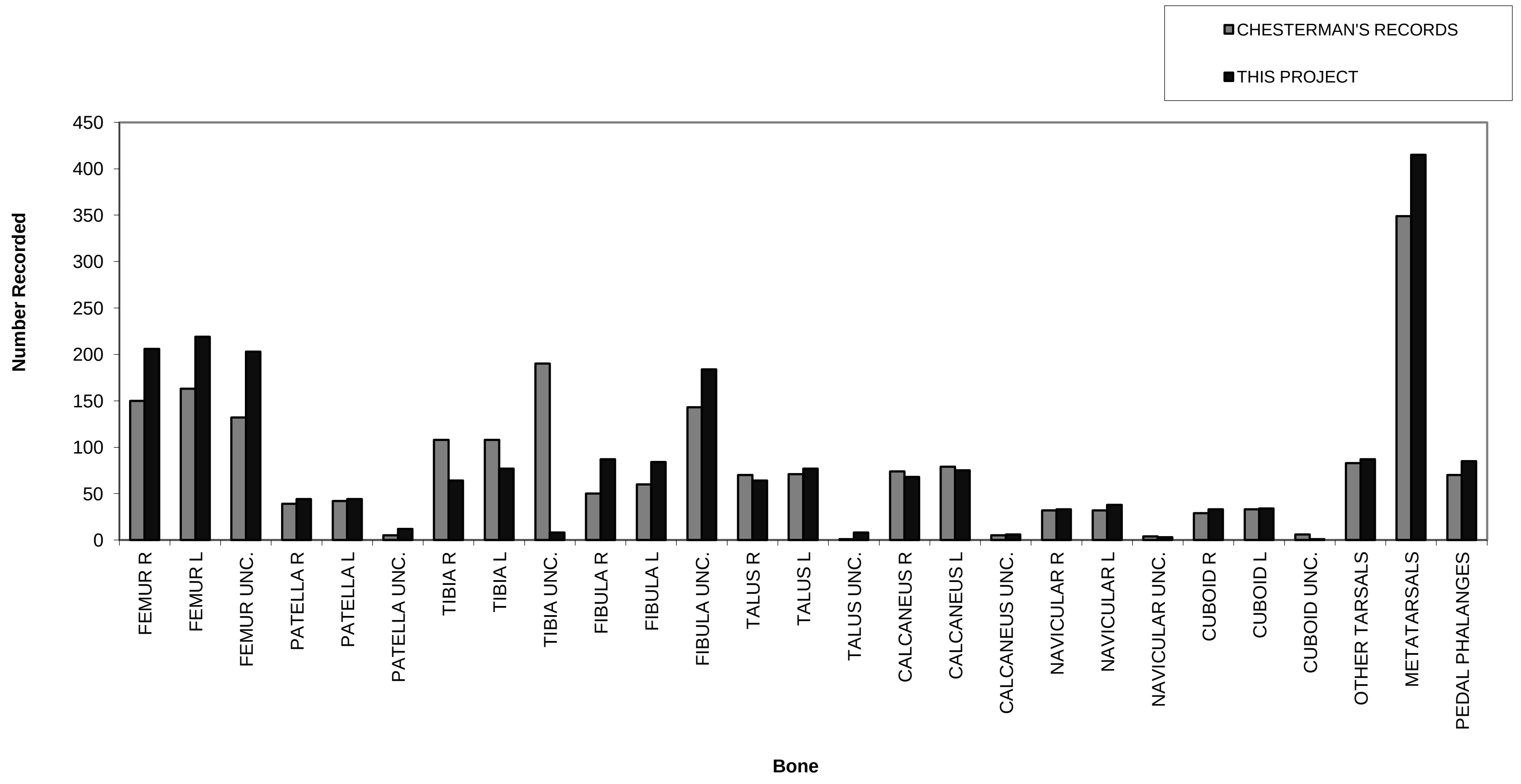


Figure 39. A comparison between lower limb bone numbers recorded previously (Chesterman 1978) and in this project.

Completeness and Side.

"*The intriguing aspect of fragmentation is that it is not restricted only to objects but that a variant on this social practice also applies to human skeletal material*."

Chapman 2000:6

It has been suggested that token deposition could have been a cultural feature and this might be reflected in patterns of bone recovery (e.g. Edmonds 1999:60-61). Bone identifiability, size and robustness appear to be more generally reflected in the number of bones of each type present in the assemblages, as expected (Waldron 1987; Cox and Bell 1999; Figure 37 above). Juvenile bones, especially epiphyses, are particularly underrepresented. Identifiability may have been an important factor, especially since there is a high proportion of juveniles (see pp200ff), since small isolated elements may not have been recognised or recovered. This is illustrated by a large number of juvenile and pathological bones in the NMS animal bones collection. Carpals, tarsals and sesamoid bones are all markedly underrepresented except for the calcaneus and talus. This affects the potential for discovering whether elements are systematically missing, especially since disarticulation normally proceeds from the extremities. For the smaller bones, recovery, although probably random, is at a very low probability and the numbers of poorly recovered bones may not be a representative sample. This will have contributed to absence of young juveniles. Following recognition of unexpected disparity in numbers of sided clavicles, completeness of bones was examined to discover whether damage was a likely cause.

Table 65. Completeness of Bones and Relationship with Side at Isbister: Upper Limb.							
Bone	**Left**		**Right**		**Side uncertain**	**χ^2 (ν=1) comparing sides**	
	n	**complete**	**n**	**complete**	**n**	**comparing number**	**comparing complete**
Clavicle	17	9 (53%)	11	5 (45%)	0	1.286:p=0.257	0.653: p=0.419
Humerus	75	4 (5%)	78	6 (8%)	9	0.059: p=0.808	0.692: p=0.405
Radius	51	2 (4%)	41	3 (7%)	1	1.087: p=0.297	-
Ulna	61	0	66	2 (3%)	4	0.197: p=0.657	-
MC1	20	17 (85%)	20	18 (90%)	2	0: p=1	0.143: p=0.705
MC2	29	17 (59%)	31	21 (68%)	0	0.067: p=0.796	0.638: p=0.424
MC3	30	23 (77%)	33	19 (58%)	0	0.143: p=0.705	2.674: p=0.102
MC4	21	7 (33%)	18	13 (72%)	1	0.231: p=0.631	14.486: p=0.0001
MC5	15	13 (87%)	22	20 (91%)	0	1.324: p=0.250	0.090: p=0.764
Capitate	9		8		0	0.059: p=0.808	
Hamate	3		2		0		
Lunate	6		7		0	0.077: p=0.781	
Pisiform	0		0		2		
Scaphoid	7		6		1	0.077: p=0.781	
Trapezium	2		3		0		
Trapezoid	0		1		0		
Triquetral	1		0		0		

‘Complete’ refers to the survival of the majority of the bone intact, including at least part of both ends, not actual completeness. Since no conjoining of these fragments was attempted, these figures for numbers of bones were calculated from the relative numbers of identifiable bone ends with adjoining shafts, hence the difference from the crude number from zones calculations above. It should be noted that in some cases, several small identifiable fragments would be expected to belong to the same bone and the method is not sensitive to this or to the issue of unfused epiphyses. There is a large number of ‘longbone fragments’ in the assemblage and these will include many of the apparently missing elements.

Table 66. Completeness of Bones and Relationship with Side at Isbister: Lower Limb.							
Bone	**Left**		**Right**		**Side uncertain**	**χ^2 (ν=1) comparing sides**	
	n	**complete**	**n**	**complete**	**n**	**comparing number**	**comparing complete**
Os coxae							
Femur	78	6 (8%)	79	3 (4%)	0	0.006: p=0.938	1.333: p=0.248
Patella	44	44 (100%)	44	44 (100%)	13	0	0
Tibia	65	6 (9%)	52	3 (6%)	11	1.444: p=0.229	0.6: p=0.439
Fibula	46	1 (2%)	49	1 (2%)	0	0.095: p=0.758	
Talus	77		64		8	1.199: p=0.274	
Calcaneus	75		68		6	0.343: p=0.558	
Navicular	38		33		3	0.352: p=0.553	
Medial cuneiform	26		26		0	0: p=1	
Intermediate Cuneiform	6		8		0	0.286: p=0.593	
Lateral cuneiform	15		5		0	5: p=0.025	
Cuboid	34		33		0	0.015: p=0.903	
MT1	36	31 (86%)	31	28 (90%)	5	0.373: p=0.541	0.091: p=0.763
MT2	36	20 (56%)	30	16 (53%)	2	0.545: p=0.460	0.083: p=0.773
MT3	34	15 (44%)	36	21 (58%)	0	0.057: p=0.811	1.922: p=0.166
MT4	31	14 (45%)	30	18 (60%)	0	0.016: p=0.899	2.143: p=0.143
MT5	31	14 (45%)	30	18 (60%)	1	0.016: p=0.899	2.143: p=0.143

Completeness appears to be related to robustness and, inversely, to length. Length exposes a bone to fracture although this may be ameliorated slightly by increased strength. Bones of the extremities are therefore more often complete than long bones. These features are to be expected (e.g. Waldron 1987; Cox and Bell 1999). There is no compelling evidence to suggest systematic differences by side nor according to removal of particular elements.

3.3 Find Location

"*... the internal constrictions were more concerned with demarcation than blocking*." Saville 1990:259

The find locations of different bones were examined to discover whether any significant variations from random distributions might exist. This might lead to interpretations regarding disturbance, taphonomic processes or structured deposition.

The database was interrogated by element, side, zone and location and the resultant tables were examined for patterning that might suggest non-random factors. It was considered necessary to compare these results with a locational analysis of bones from Chesterman's manuscript notes in order to discover whether these were real attributes of the tomb or artefacts from poor curation.

The problem of intermingling of material from the north end of Isbister tomb (SC1, SC2, ST1 and ST2) seems insurmountable. Labelled distinctions between bones recovered from SC1 (IS[128], BC2c) and between those recovered in 1958 and 1976 may be meaningless. The number of cranial fragments recovered from SC1 in 1976 (IS[128]: 5 significant cranial fragment-zones, 34 cranial fragments) elsewhere in this area (IS[127]: no significant fragment-zones, 68 cranial fragments) is trivial compared with those from the remainder of the northern area (IS[126]: 318 significant fragment-zones, 580 fragments). The north end can therefore only be addressed as a single entity. There are minor discrepancies in the relative numbers of left and right bones and in the relative numbers of particular phalanges, tarsals and metatarsals within particular catalogue numbers that can be resolved through combining all the elements recorded from IS[126], IS[127] and IS[128]. If the side cells were utilised as ossuaries for secondary deposition from the stalls, then this might be reflected in the comparative numbers of bones in the stalls. The order of loss from the skeleton is reasonably well understood and could be fitted to the element distribution to suggest the degree of skeletalisation that had occurred and the locations in which it happened but only if recovery was consistent. There is a confounding influence from the limited sieving employed (Hedges 1983:20), which may have caused a distribution bias for particular bones near the entrance.

Limb bone distribution suggests a general absence from ST4 that is quite marked but could be due to poor labelling. Neighbouring areas (ST3, ST5) produced significant quantities of such bones and the number of patellae recorded from ST4 is relatively high. The numbers of patellae recorded may accurately reflect initial deposition because these are robust and survive well but are small enough that they may escape disturbance. Cranial fragment data suggests a similar density in ST4 to neighbouring areas. It is significant that these are better represented than limb bones for ST4. It seems likely that the large number of limb bones with no location recorded (Table 67 below) actually came from ST4, which would resolve the anomaly but cannot be proven.

The suggestion that "each skull had a pile of bones" (Hedges 1983:20) is not supported by the site photographs (held at RCAHMS, Edinburgh).

Table 67. Simplified Limb Bone Location at Isbister.							
Bone	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
Scapulae	6	13	0	0	2	0	37
Clavicles	15	8	19	1	4	0	22
Humeri	52	21	63	2	24	21	34
Radii	14	9	52	2	16	0	46
Ulnae	12	17	45	1	16	0	62
Femora	38	57	114	9	5	9	39
Patellae	16	12	18	20	4	6	10
Fibulae	0	24	60	0	20	0	0
Table 67 presents simplified estimates of numbers of bones represented in different areas of the tomb according to identifiable skeletal parts. For the scapulae, only zones 2, 3 and 5 were considered because these are robust and readily identifiable.							

Table 68. Find Locations of Carpals at Isbister.							
Carpal	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
Capitate	2	1	4	0	5	0	4
Hamate	1	0	2	0	1	0	1
Pisiform	1	0	2	0	0	0	0
Scaphoid	0	0	6	0	2	0	5
Trapezium	0	0	2	0	0	0	3
Trapezoid	0	0	1	0	0	0	0
Lunate	3	0	5	0	1	0	4

Table 69. Find Locations of Metacarpals at Isbister.							
Metacarpal	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
Unidentified	17	6	17	0	5	0	16
First	12	1	15	0	6	0	12
Second	13	4	20	1	10	0	14
Third	14	6	27	1	4	0	11
Fourth	5	5	12	0	4	0	13
Fifth	12	1	5	0	8	0	12
TOTAL	**73**	**23**	**106**	**2**	**37**	**0**	**78**

Table 70. Find Locations of Manual Phalanges at Isbister.							
Phalanx	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
First row	24	0	29	0	15	0	31
Second row	8	4	22	1	3	0	12
Third row	1	1	3	0	0	0	1
First ray, proximal	2	1	3	0	2	0	9
First ray distal	0	13	22	0	0	0	7

Table 71. Find Locations of Tarsals at Isbister.							
Tarsal	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
Calcaneus	44	19	56	2	14	6	7
Talus	47	14	51	2	17	12	6
Cuboid	14	10	24	0	15	0	5
Navicular	19	9	24	3	8	0	10
Medial cuneiform	14	2	23	0	5	0	5
Intermediate cuneiform	3	1	4	0	1	0	4
Lateral cuneiform	4	1	9	0	1	0	6

Table 72. Find Locations of Metatarsals at Isbister.							
Metatarsal	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
Unidentified	22	7	19	0	4	0	15
First	14	16	28	3	9	1	9
Second	22	9	21	0	10	0	7
Third	21	13	22	0	10	0	8
Fourth	14	8	25	0	11	0	7
Fifth	10	8	23	1	10	0	11
TOTAL	**103**	**61**	**138**	**4**	**54**	**1**	**57**

There are inconsistencies in the numbers of different metatarsals between the 'North end' and SC1 separately (see Table 72 above). This can be resolved if the two are combined as a single entity and suggests that bones recorded as belonging to IS128, BC2c (SC1) are not distinct from the remainder of the North end.

Table 73. Find Locations of Pedal Phalanges at Isbister.							
Phalanx	**N END**	**SC1**	**ST3**	**ST4**	**ST5**	**SC3**	**Unstrat/ no location**
Proximal	13	2	6	0	0	0	2
Intermediate	0	0	1	0	0	0	1
Distal	0	0	3	0	0	0	1
First ray, proximal	2	5	9	1	8	0	5
First ray distal	3	1	8	0	5	0	10

The numbers of phalanges (Tables 70, 73) are too small to permit adequate analysis but it will be observed that they reflect the same patterning as the other extremity elements.

The calcaneus and talus (Table 71) are particularly appropriate as indicators of distribution. These are relatively large, robust and recognisable bones, therefore less prone to loss through fragmentation, erosion or failure of recovery. Examining records suggests that ST4 may have contained more bones than evident from labelling. Those counted were labelled simply BC3 and ST4 without any IS number, although ST4 had four distinct IS numbers allocated.

Minor discrepancies in location labels were recognised between the bones and Chesterman's records that might best be ascribed to errors of data entry or copying. Some errors may be systematic, such as the use of inaccurate location codes or erroneous bone identifications. Discrepancies may sometimes be accounted for through elements unidentified to side. Lorimer noted that some of her observations did not closely agree with those of Chesterman (Lorimer 2000) and the locational information available may reflect Lorimer's interpretations of Chesterman's notes rather than original distribution. The distribution of bones suggested by the information labelling the assemblage may therefore be incomplete, erroneous and misleading.

The apparent absence of bones of the extremities (other than calcaneus and talus) from SC3 could be consistent with secondary deposition. Examination of Chesterman's notes however demonstrates that such bones were recovered from that area; they were simply not later identified. Similarly, the absence of information on the scapulae simply reflects a failure of identification – only 11% of Chesterman's scapula entries did not have a location, compared with 62% of the assemblage now (38 of the 61 fragments including scapula zone 3 - the relatively robust glenoid region - have no associated locational information).

Numerous metacarpals and metatarsals are labelled as coming from IS115, BC4 and IS113 BC5 (both ST3) (Tables 69, 72) but far fewer were listed by Chesterman. Many longbone fragments were labelled as BC4 (corresponding to IS115, ST3) but comparison with Chesterman's records suggest that they may have come from BC4a, which corresponds to IS114, ST4. A small number of fragments labelled as coming from different areas were found to conjoin across modern fractures. The Isbister labels cannot be considered reliable enough for location analysis. Although they are often incomplete, the crania may be an exception: many fragments retain Chesterman's ink or pencil markings, which together with the detailed descriptions gives some confidence in identifications.

Subtle variations are incapable of resolution because of the poor original recording: distinctions between areas of the tomb were apparently not observed consistently and identification of layers was not robust. The area excavated in 1958 can only be considered as a single unit. Only the broadest tests of variation in distribution are therefore possible for the Isbister assemblage and even these may be invalid.

Table 74. Numbers of Crania Recorded from Different Areas at Isbister.

	North of ST3	**ST3**	**South of ST3**
Male adults	7	1	16
Female adults	6	0	8
?sex Adults	3	3	2
Juveniles	5	1	9
Total	21	5	35

NB This table does not include external deposits, unlabelled crania or small fragments.

The southern area of Isbister tomb contained more crania than the north (χ^2 =3.5: p=0.061). Closer examination revealed that the difference was particularly due to the distribution of male adults and juveniles. Juvenile and male adult crania appear to have been disproportionately recorded or recovered from SC3, ST4 or ST5 compared with SC1, ST2 or ST1 (ST3 was considered to represent the middle and entrance, and inappropriate to include in this examination), whereas female crania appear to have had an equal chance of having come from either end. A chi squared test comparing the sexed adults indicated that the difference in distribution was not significant (χ^2 =0.589: p=0.443).

3.4 TAPHONOMY

He's not wearing anything at all!

The Emperor's New Clothes, Hans Christian Anderson

Taphonomy at Isbister

Taphonomy at Isbister has been discussed previously (Baxter 1999, 2001; Lawrence 2006) but requires summary here. Almost all elements examined from Isbister displayed post-depositional fractures. One fragment (an ulna) displayed rodent gnaw marks but these were tentatively attributed to modern activity.

The condition of the Isbister fragments was broadly similar. Though mottled, the bones were overall very pale brown in colour (Munsell colour 10YR8/4) and had post mortem fractures. There was often moderate mechanical bone loss marginally but surfaces were usually sound. There was commonly a superficial coating of a clear brown 'varnish' and adherent mineral deposits (Figure 40).

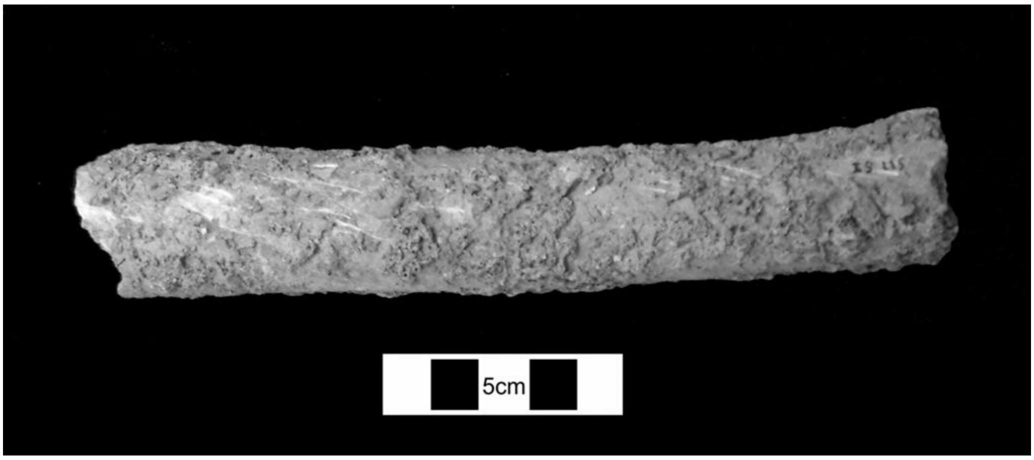


Figure 40. Concretion. A typical case of mineral concretion seen at Isbister, associated with brown colouring; note scratch-marks from failed cleaning attempts in the past.

Table 75. Taphonomic Variables at Isbister (after Lawrence 2006).		
Severity	**Surface Obscured**	**Weathering**
5 Severe	4 =0.1%	0
4 Very heavy	198 =3.3%	1
3 Heavy	749 =12.7%	34 =0.6%
2 Moderate	1704 =28.8%	45 =0.8%
1 Slight	422 =7.1%	48 =0.8%
0 None	2839 =48%	5790 =97.8%

The degree of weathering recorded was generally trivial (Table 75) and had sometimes occurred after the fragment had suffered varnish/concrete/stain damage. The actual weathering damage is therefore provisionally ascribed to post-excavation processes. There was little light bleaching. Close reading of Chesterman's work suggests that he used the term 'bleaching' simply to mean the loss of greasy texture from bone rather than holding any meaning for colour and the suggestion of exposure to sunlight as a causative factor was inappropriate (Lawrence 2006b). Longbones were found to have suffered extensively from transverse and longitudinal fracturing but the pale colour of the fractured surfaces indicates that this took place predominantly during excavation or later. Chesterman noted this in his study and so it may be assumed that many of these fractures existed before his examination in 1978.

Occasional bones exhibit focal hemispherical erosions, sometimes with a discoloured umbra, all less than 1mm in diameter (see Figure 41 below).

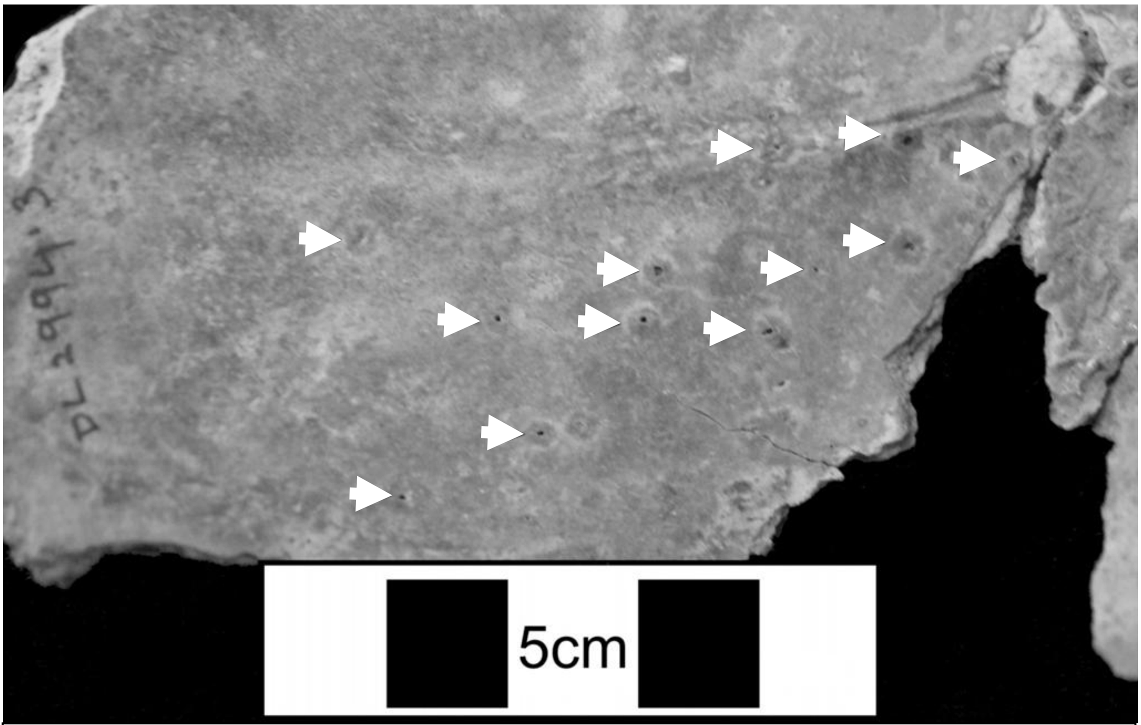


Figure 41. Focal erosion with discoloured umbra (arrowed). IS(7074) endocranial surface.

The ‘varnish’ coating was evident on some fractured surfaces and apparently respected the outline of objects resting on bone surfaces (Figure 43, p187 below). It was not readily soluble in water or acetone. This suggests that decay products may have developed on broken bones in the tomb or that the coating was applied after excavation: initial storage in open fish boxes may have contributed. The most likely explanations are post-excavation contamination or deposition *in situ* of some decay product derived from fats or proteins. It seems possible that dissolved organic matter was brought to the bone surface by capillary action and then set as a solid, perhaps polymerisation of collagen. Some groups of bones did not display significant adhering concretions and on some of these, more typical decay products and pink staining were apparent. One cranium had cement adhering (Figure 42 below) and another had paint.

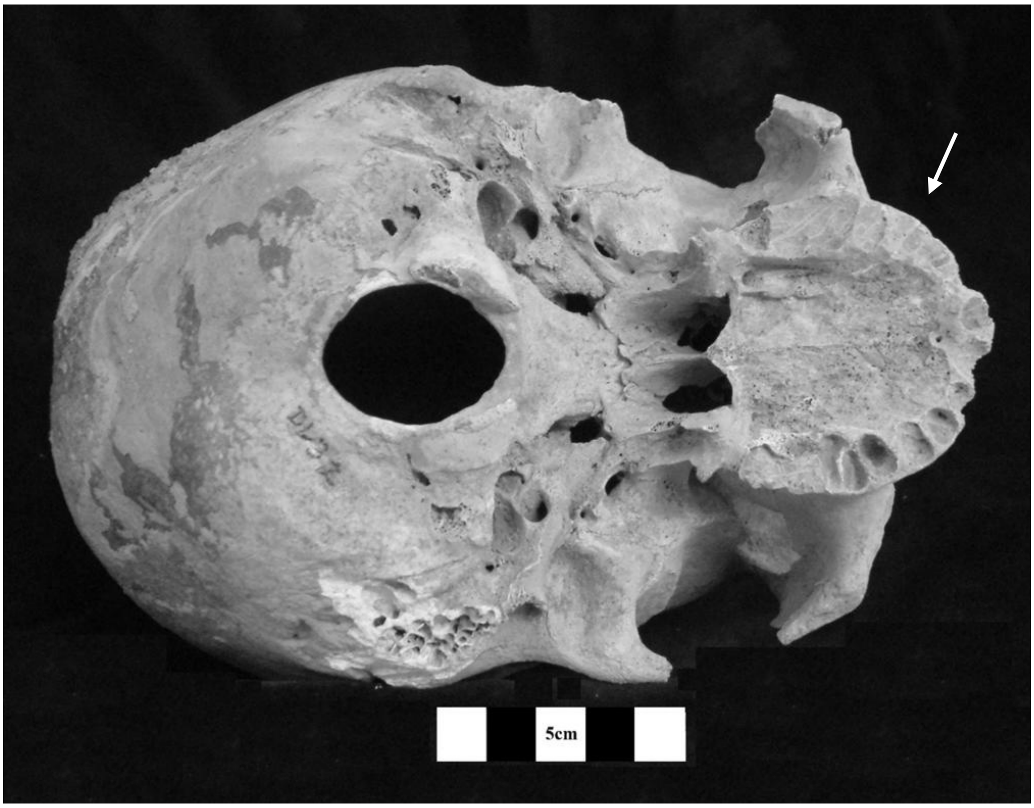


Figure 42. An unusual case of taphonomy: the maxillary alvaeoli are filled with cement!

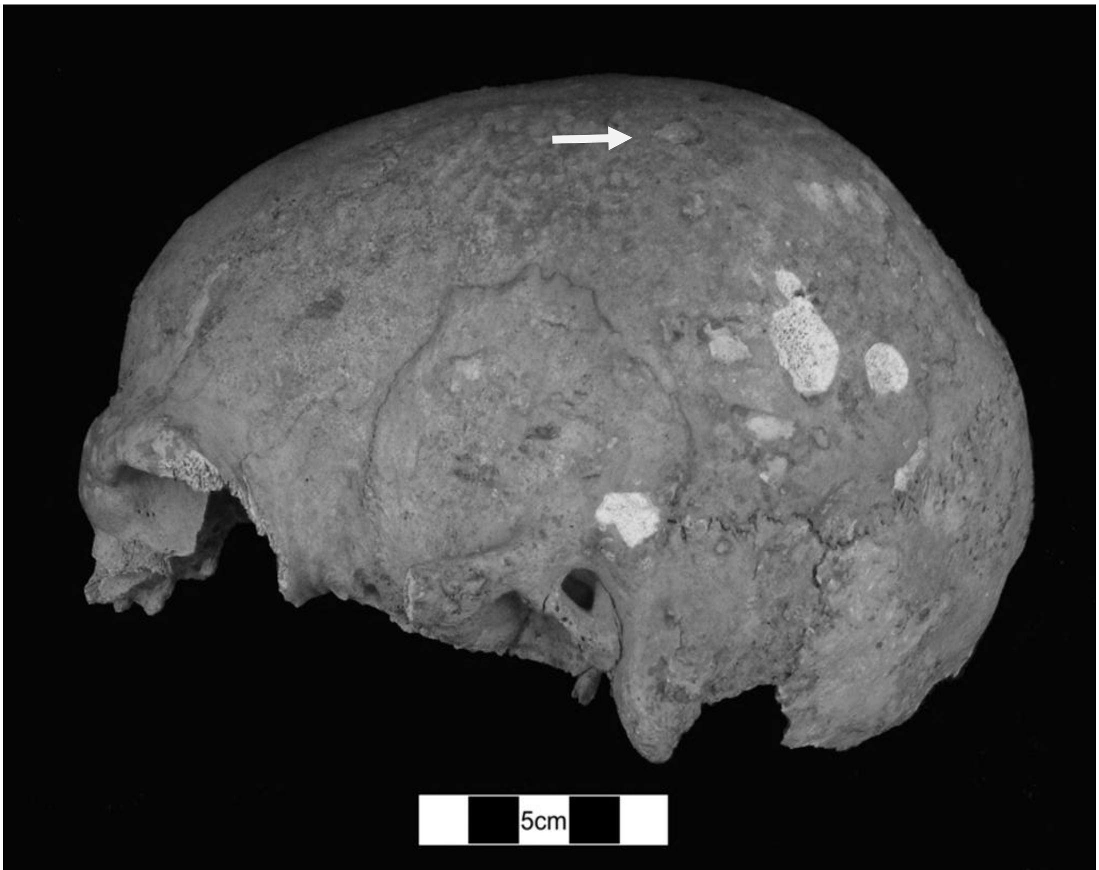


Fig. 43. 'Varnish' respecting lost superficial object (arrowed). IS(2694).

Staining from decay products is clearly present on many crania but does not necessarily relate to the decay of any particular individual's cadaver since this was a communal interment site and liquor might derive from later deposited bodies. These stains were typically reddish-brown (e.g. Figure 44 below) in many different shades and intensities but could exist as either a matt coloration to the bone or a glossy surface patina. In some cases, decay products appear to have acted as glue, facilitating the adherence of mineral dust and fragments (Figure 40). This may support a collagenous rather than fatty origin. One (all too short) experiment found that remains in a stone-built tomb retained observable superficial decayed organic matter through to the experiment end (Jonuks and Konsa 2007).

Figure 44. Localised red decay product staining.
IS(4440) inferior aspect (also note angled condyle form).

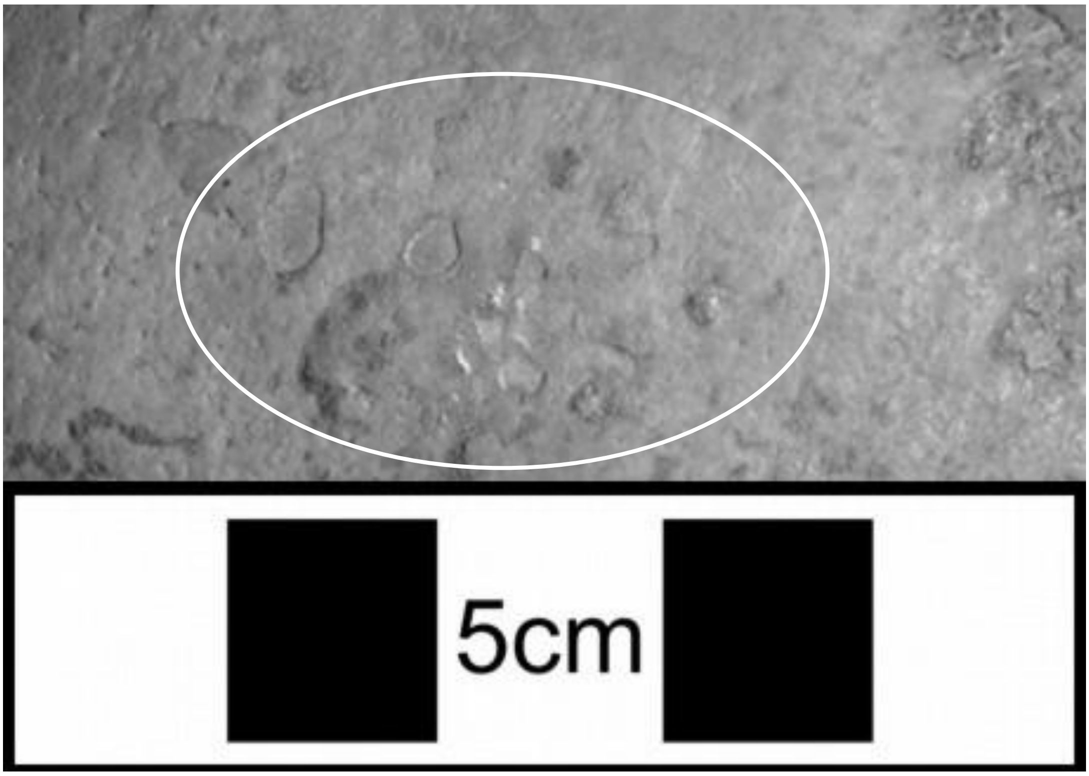


Fig. 45. Crystal formation causing exfoliation. IS(4440) superiorly.
(The bright white material in the photograph is clearly raising the endosteum)

Pale grey staining was observed on some crania, both endocranially and ectocranially in the same areas, in some cases beneath the bone surface, causing blistering and exfoliation. This was clearly efflorescence from the migration of soluble salts through the bone, probably brushite formation. It is likely that this occurred through capillary action involving only trace surface moisture (e.g. from condensation in the tomb) but was associated with variations in humidity permitting crystal precipitation. Faint coatings of this sort were observed in areas of crania that were opposite surviving silt deposits and staining from decay products. This suggests that generally these deposits developed *in situ* in the tomb environment. Where deposits had precipitated beneath the bone surface, localised exfoliation mimicked pathology by creating shallow, sharp-edged, smooth-bottomed depressions in the vault – these were distinguishable from traumatic lesions by the presence of white crystals, absence of fractures or spalling and the nearby presence of ‘blisters’ of bone (similar in appearance to osteomata), where the surface was lifted as crystals grew (Figure 45 above).

Stains interpreted as deriving from fungal activity were sometimes present. These were small patchy areas usually grey, observed in bands above decay product stains.

Although the Isbister crania had been more-or-less cleaned as part of the excavation and post-excavation processes, there were substantial silt deposits endocranially in the more complete examples. These deposits must have been washed in by ambient water and sunk to the low point in the cranium, where they accumulated. These deposits indicate the presence of water percolating through the tomb after backfilling had occurred and reflect the planar orientation of the crania in this environment. In some instances, there is a sharply edged band around the cranium that indicates the earlier presence of another substance, since lost. The location of these silt deposits matched closely the distribution of staining from decay products and was opposite to the areas of salt precipitation. This shows that all these processes usually occurred with the crania in the same position.

It was observed that the empty tooth sockets of mandibles had fine mineral deposits firmly attached and obscuring the bone. This was rare in the crania, although such deposits occurred in various locations of the vault. It seems that these deposits occurred predominantly on the upper surfaces of the bone in the burial environment and that in the cases of the mandibles but not generally of the crania, the sockets were uppermost. This would perhaps be expected given the shape of the human mandible and may imply that mandibles frequently lay directly on the flat tomb floor.

Numerous crania exhibited taphonomic scrape marks and modern tool marks. Possible cuts were rare and there was only one likely example (IS(7115), Figure 47), even here there was some doubt, because of accompanying taphonomy.

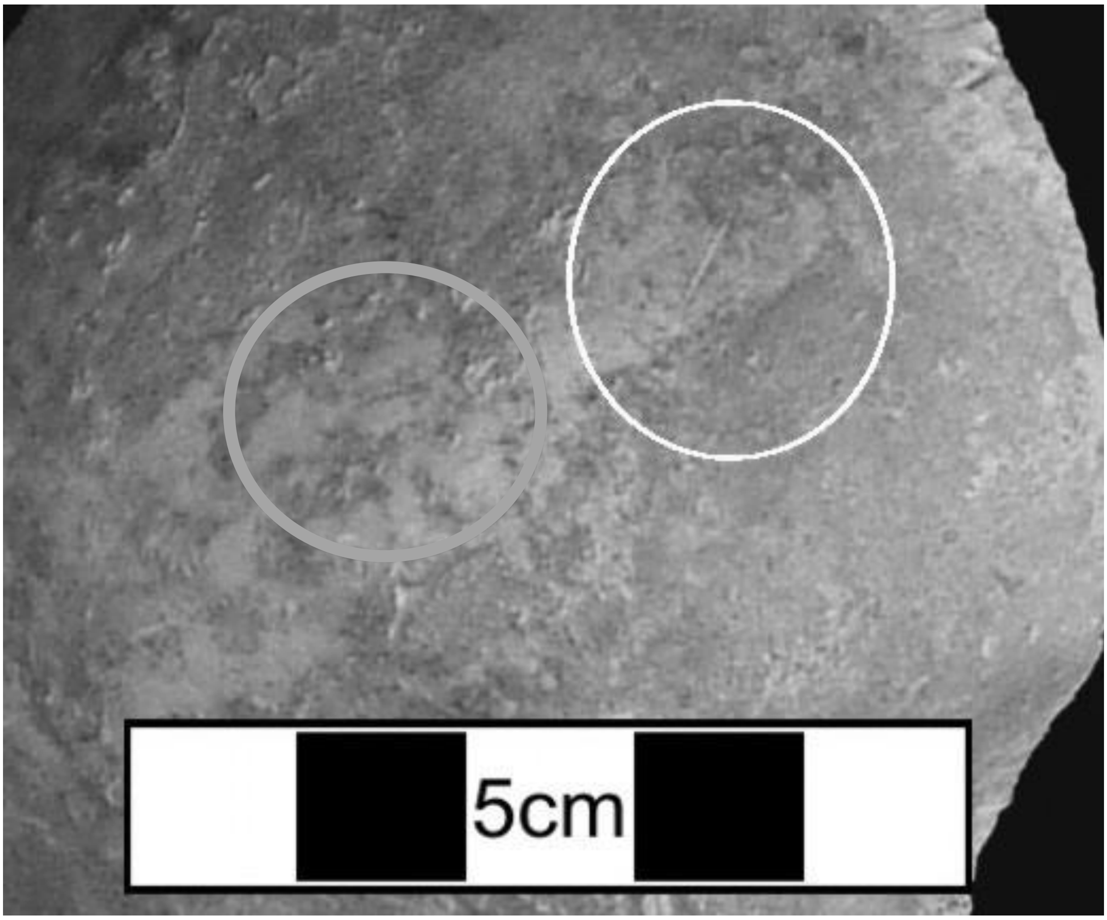


Figure 46. Cranium IS(7115), showing taphonomic features:
scrape (circled in grey) and cut (circled in white)

Figure 47. Single bones could exhibit a range of preservation. IS(<u>7279</u>) (left) and IS(<u>7282</u>) (right) varied from very good to very friable according to area across the bone.

Scoring for some features could be complicated by variation across any individual bone or fragment (e.g. Figure 47). Both colour and preservation were particularly variable in some crania, presumably because of size.

Taphonomy at Banks

It was expected that the use of modern excavation practices with 100% sieving at Banks would permit a superior quality of observation and analysis. This potential has unfortunately been limited by partial excavation.

During both the assessment and the first phase of excavation proper, the opportunity was taken to measure the pH of surface water and soils within the monument using indicator paper. All were slightly acid (pH5). In damp or waterlogged conditions, this would be expected to result in progressive dissolution and damage of bone.

The Banks assemblage displayed few of the more spectacular taphonomic conditions observed at Isbister. There was little concretion, no adhering stone and no brushite formation or 'varnish' coating. When first excavated, many of the bones were waterlogged and highly fragile. Their initial fragility led to fractures from excavation and handling. Some exfoliation and cracking occurred during excavation and drying and although damage from this was generally trivial, it is possible that future analysts will mistake it for erosion or weathering in antiquity. Surfaces tended to exfoliate at the least disturbance and typically left a pale surface, even where the lost bone was darkly stained. Some superficial bone adhered to the clay soil matrix and could not be recovered. Most elements displayed mottled coloration that typically included mid or dark grey areas and pale to mid brown areas.

The excavated bones recovered became firmer as they dried. All were clean, dry and stored in labelled polythene finds bags at the time of analysis. None of the bones had been directly marked with identification codes and none was treated with any consolidant.

Figure 48. Cranium BSR(140), shown *in situ* and after cleaning. The areas of perforation and erosion are notably on the uppermost surface as it lay when discovered and are probably related to dripping from above.

Erosion of bone surfaces at Banks appears to have been localised and was only significant on a small number of bones, on particular aspects. This erosion was probably especially related to exposure to dripping water or contact with damp surfaces over long periods in antiquity. One example (BSR(140), Figure 48) was perforated on its most superior (as discovered) surface but was also found to have a generally eroded area on the left side, and perforation on the most inferior surface. This suggests that these areas were more exposed to leaching whilst other bone areas were not. The most likely explanation is of water dripping onto the cranium from above, flowing down the left side and of water collecting on the stone surface below, either from percolation or condensation. Capillary action through the bone may also have been involved. There is no indication of root etching on any bone, which indicates that there had been no vascular plant colonisation of the burial environment.

Fragmentation during excavation was recognised from rough, irregular fractures that were pale relative to adjacent bone surfaces (Figure 49). Such fragmentation may also have occurred during the earlier machining.

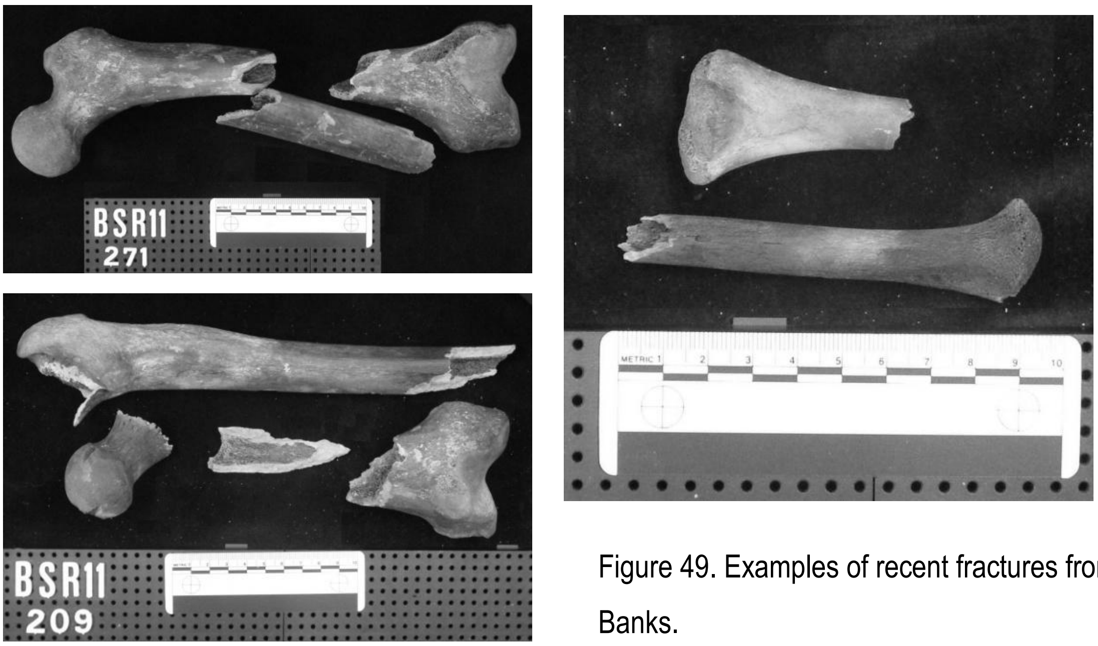


Figure 49. Examples of recent fractures from Banks.

There are areas of dark rough material that appear to be superficial on the superiorly oriented surfaces and yet are associated with areas of bone erosion. A similar feature was noted at Parc le Breos Cwm (Whittle and Wysocki 1998). It is likely that this material is recrystallised bone mineral darkened by soluble salts absorbed from adjacent deposits. Much of the Banks bone has a dark appearance, suggesting that mineral uptake was widespread and not necessarily related to erosion. Colour varies from mid-brown to mid-grey but many bones were mottled or banded, suggesting that mineral uptake varied on a very localised scale (Figure 50), even more than at Isbister.

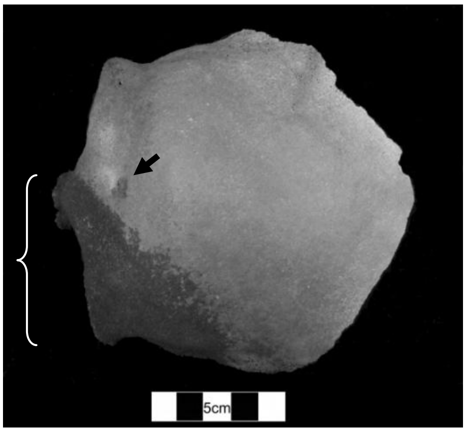


Figure 50. Cranium BSR(150), showing well defined mineral deposits (bottom left) and taphonomic damage medially (centre left, arrowed).

Erosive damage varied from surface cracking and exfoliation of geographic areas to focal ‘pinprick’ erosions. Much eroded bone was relatively pale, which suggests recent surface loss. In some cases, this may be because the bone surface was already exfoliating but the surface itself was only lost during excavation or cleaning and failed to survive because of its fragility (Figure 51). Erosion was only rarely so deep that the bone outline was lost but did occur with this severity (e.g. Figure 52). Loss could be confined to a single surface, which probably reflects bedding within the deposits.

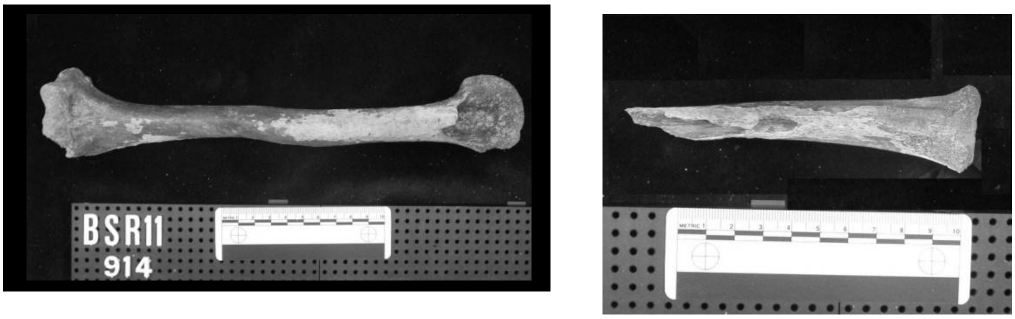
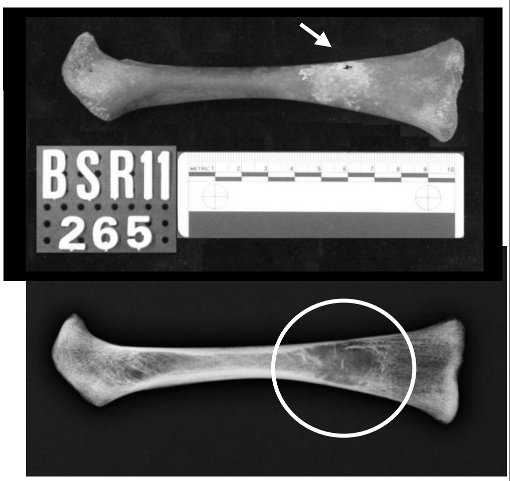


Figure 51. Examples of recent exfoliation from Banks. Note the pale colour where the periosteal surface was protecting the underlying bone prior to excavation.

Figure 52. Femur BSR(962): heavy erosion and fragmentation.

Juvenile bones generally appear to exhibit less erosion than adult bones. Juvenile bone contains relatively more collagen, which may help to protect the soluble apatite component from chemical attack.

Figure 53. Juvenile femur BSR(1372), with radiograph below. Erosion is clearly exhibited (arrow) but is associated with a possible pathological lesion in the medullary cavity visible below (circled).



In some cases, it is difficult to distinguish between taphonomy and pathology. BSR/265\ (Figure 53) appears to have recent damage but there is a coincident internal ovoid feature apparent on x ray: this may indicate perforation from erosion but may possibly be from a space occupying lesion that is coincidentally near modern damage or that contributed to fragility at that point.

Focal erosion of several bones left pale hemispherical depressions under 1mm in diameter (Figure 54). The pale colour is likely to indicate a recent erosive event that occurred diffusely over the bones but had affected relatively few random points. Similar features have been recorded at Isbister (see Figure 41 above), Knowe of Rowiegar (tibia ABDUA90015, Figure 55) and Quanterness (Rebecca Crozier pers. comm.). Some examples are typified by a discoloured umbra around the small circular surface perforation. The focal nature suggests that these are unlikely to be geochemical in origin (although see Andrews 1990:Fig.6.6L), and there is no linear erosion indicative of root activity, so these features seem most likely to be due to some fungal, bacterial or small invertebrate infestation.

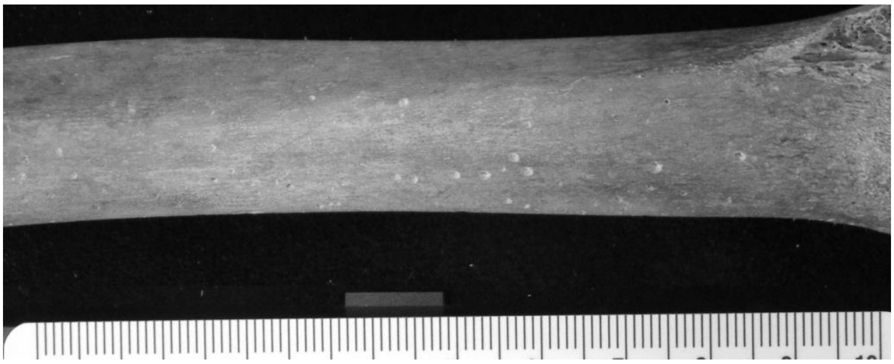


Figure 54. Superficial focal erosion at Banks (scale in mm).

Figure 55. Deeper Pitting (Rowiegar ABDUA90015).

Evidence of abrasion is widespread where the bone surface survives, varying in form from faint areas of rubbing, through distinct scratches, to sharp 'chipping.' This is consistent with the bones moving across rough stone surfaces. There is no apparent patterning to abrasions except a tendency for the maxillary alveoli (the edges of the tooth sockets) to be affected. This may be due to their vulnerability but could reflect a tendency for crania to be placed on their inferior surfaces (i.e. the right way up) so that these areas become more damaged.

BSR(213) parallel scores created in antiquity, in this case possible cuts.

BSR(1339) similar modern damage, probably a modern tool mark.

Figure 56. Score marks on crania from Banks.

In one instance, there is abrasion of the inferior surface of the occipital, sphenoid and temporals but not the maxillae, in a manner that suggests placement on a surface with the viscerocranium protruding from the underlying surface. This may be evidence supporting the hypothesis that crania might have been placed in aumbries (Barber 1992:24).

A feature of the Banks assemblage thus far is the general absence of bones in articulation. The exception is finds BSR(1399)-(1410), a series of 12 cervical and thoracic vertebrae recovered from the central chamber close to the western side cell entrance. It is possible that articulated bone will survive elsewhere but the evidence so far is consistent with an ossuary function for the western cell.

The differences in mineral deposition on the bone surfaces at Banks and Isbister indicate that there were different depositional environments inside the two tombs. It is possible that this relates to differences in water percolation regimes.

Variation in the appearance of focal erosion of bone surfaces between Isbister, Banks and Rowiegar (Figures 41, 54, 55 above) may indicate minor differences in local environment, perhaps temperature and humidity at the time of deposition, that affected biological activity.

3.5 Demographic Features

Age Distribution from the Isbister Bones

Age attributions from epiphyseal fusion were limited because fragmentation and commingling largely prevent assessment or comparison of multiple observations. Very few partly fused epiphyses were identified (Tables 76, 77).

Table 76. Epiphyseal Fusion of Medial Clavicles from Isbister.

Side	Unfused	Partly formed	Fused
Left	5	1	16
Right	4	0	10

Table 77. Epiphyseal Fusion of Femora from Isbister.

Location	Unfused	Partly fused	Fused
Left head	22	2	50
Left greater trochanter	22	0	43
Left lesser trochanter	22	0	43
Left distal epiphysis	12	0	49
Right head	15	1	53
Right greater trochanter	15	0	43
Right lesser trochanter	14	0	37
Right distal epiphysis	14	0	48
Unsided head	0	0	15

The number of adults in the assemblage is approximately 2.5 times the number of juveniles. Few individuals died with the femoral epiphyses in a state of partial fusion: this would support the mortality pattern suggested by the dentition, in which there is an absence of individuals in the teenage years. The summarised age group sizes are 37 adult, 13 young adult and 14 juvenile.

The crania gave the largest sample and best evidence for both age and sex in the assemblage. The overall age distribution has particularly poor adult age resolution because of fragmentation and pathology. Cranial suture obliteration was recorded in detail but attribution of age by this method was inhibited by evidence for premature craniosynostosis. Dental attrition was recorded in detail but attribution of age by this method was inhibited by widespread ante-mortem tooth loss, missing teeth and dental abnormalities. Juvenile crania were reliably aged according to dental development but, for adults, the use of broad categories was necessary.

<table>
<tr><td colspan="3">Table 78. Age Distribution at Isbister from Dental Development and Attrition.</td></tr>
<tr><th>AGE</th><th>Maxillary</th><th>Mandibular</th></tr>
<tr><td>0-1 year</td><td>1</td><td>1</td></tr>
<tr><td>1-2</td><td>2</td><td>6</td></tr>
<tr><td>2-3</td><td>1</td><td rowspan="2">5</td></tr>
<tr><td>3-5</td><td>5</td></tr>
<tr><td>5-8</td><td>6</td><td>9</td></tr>
<tr><td>8-12</td><td>4</td><td>5</td></tr>
<tr><td>12-17</td><td>2</td><td>3</td></tr>
<tr><td>18-25</td><td>18</td><td rowspan="4">Adults not fully assessed because of tooth loss: adult MNI=51 of which YA=12</td></tr>
<tr><td>25-35</td><td>5</td></tr>
<tr><td>35+</td><td>5</td></tr>
<tr><td>Adult indeterminate</td><td>20</td></tr>
<tr><td>MNI</td><td>69</td><td>80</td></tr>
<tr><td colspan="3">NB. Disparate numbers result from exceptional fragmentation in the juvenile groups.</td></tr>
</table>

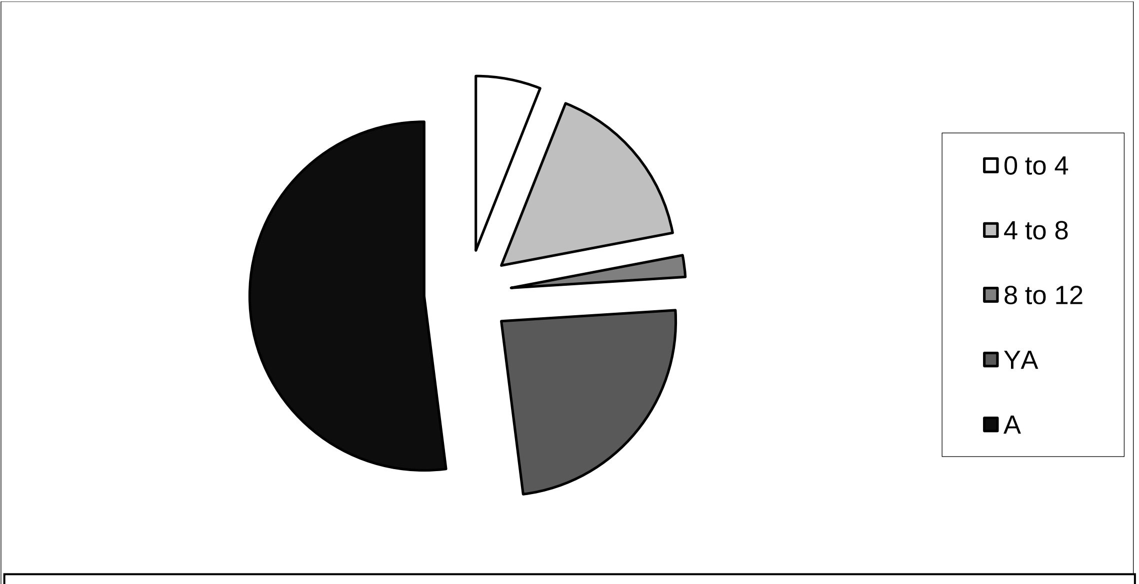


Figure 57. Age distribution at Isbister from cranial assessment.
Juveniles in 4-year groups, YA=young adults, A=adults.

Figure 57 summarises the age distribution given by assessment of the Isbister crania. Note the disproportionately large numbers in the 4-8 years old and young adult categories.

Table 79. Cranial Age Distribution at Isbister.

Age Group	Number
Infants (0-1)	2
Children 1-5	13
Children 6-11	13
Adolescents (12-16)	2
Young Adults (17-25)	13
Adults 25+	38

NB. MNI=85, some crania lost; juvenile ages represent most likely age at death.

Table 80. Minimum Number of Individuals (MNI), calculated from aged mandibular fragments.

Age Group	0-2	2-4	4-7	7-9	9-12	Adolescents	Young adults	Adults	Total
MNI	7	5	9	5	0	2	12	39	79

Note that not all fragments could be assigned to an age group and not all could be conjoined.

Sexing the Bones from Isbister

Or have [ye] seen Johne Tamson?

They say his wife has run away.

Trad. North Scottish folksong (Child 1964:10)

(Jock Tamson is also the nickname given to IS(7354) by Mr. Simison)

Bones and fragments could only be considered for sex attribution individually, which reduces confidence in results.

Cranial Sex Attribution

The crania were initially assessed as being predominantly of a male type due to the pronounced rugosity of sexually dimorphic features: Thirty-nine crania were classed as male and 16 as female: a ratio of almost 2.5:1. Robustness of the Isbister population was feared to affect sexual dimorphism and bias sex assessment. The presence of premature craniostenosis introduces problems of abnormal mechanical forces affecting muscularity and form, further decreasing confidence in sex attributions. The crania were therefore reassessed, scoring each trait independently to discover any systematic anomalies. Results suggested that males outnumber females by 2:1 (Table 81 below). The number of female crania identified was virtually the same in both studies but the number of males was reduced in the second analysis, mostly because some incomplete crania were excluded as incapable of returning a definitive score.

Table 81. Sex Determination from Adult Crania at Isbister.

Sex	Female	Probably Female	Indeterminate	Probably Male	Male
MNI	9	6	8	11	17

Attribution of sex in juveniles will not be discussed because the assessed sample was small and the methods probably not informative (Scheuer 2002). Individual adult trait scores were compared to discover whether they demonstrated any informative patterning: whether the individual criteria scores were related, as a check on their reliability and validity as sexing criteria.

Table 82. Adult Sex Attribution by Individual Cranial Trait Observations.

Criterion	Female	Probably Female	Indeterminate	Probably Male	Male
Mastoid Process	13 (n=26) (13L,13R)	5 (n=10) (5L,5R)	10 (n=20) (10L,10R)	12 (n=23) (11L,12R)	18 (n=34) (16L,18R)
Supraorbital Ridges	5	9	10	16	12
External occipital protuberance	11	6	8	8	10
Frontal bosses	11	9	4	8	11

NB the figures in brackets for mastoid process are for total elements, left side and right side respectively and indicate that numbers are consistent for each side. Individual side scores may vary from overall attribution. Other aspects (e.g. orbit shape and margin) were examined but were not recorded in sufficient numbers to provide suitable data for this table.

Different criteria imply different sex proportions (Table 82), varying from about 1:1 (external occipital protuberance robusticity and expression of the frontal) to 1 female: 2 males (mastoid process and supraorbital ridge robusticity).

Metrical dimorphism was investigated but was inhibited by fragmentation, so that multiple measurements, especially zygomatic breadths and measurements requiring the viscerocranium or inferior neurocranium, could rarely be made;

some measurements were affected by pathology. The most common and reliable measurements were cranial length and breadth. These were plotted and compared with the morphological sex attributions.

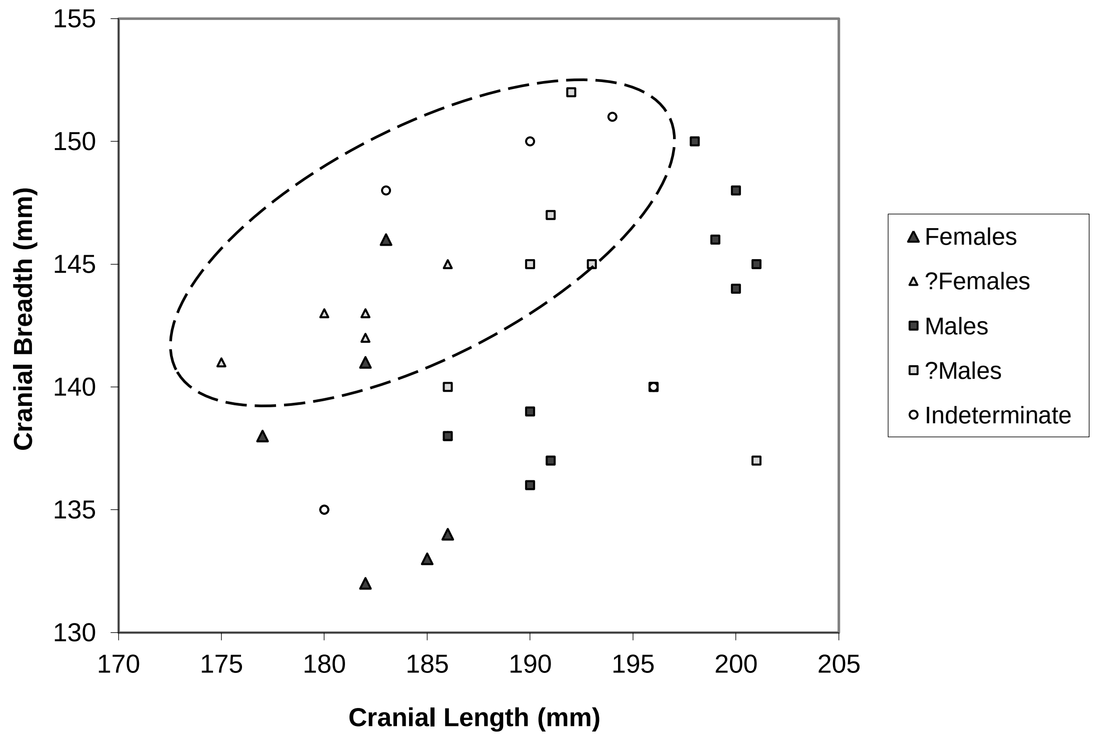


Figure 58. Cranial size and sex attribution at Isbister. Note the different proportions (circled) of the less confidently sexed crania compared to the confidently sexed group.

The metrical results support morphological attributions of sex to the crania, with a cutting point at cranial length = 186mm and little overlap (Figure 58). Males generally have longer crania but this could relate to the development of characteristics of robusticity used in assigning sex and may not be independent.

A curious aspect of the plot is that those crania that were less confidently sexed (i.e. scored 2(=?F) and 4(=?M)) may be distinguished as clusters distinct from those that were confidently sexed (i.e. scored 1(=F) and 5(=M)). The less confidently sexed crania generally exhibit a greater cranial breadth relative to length. Only males (5=M) have highly correlated length and breadth dimensions ($r=0.81$, compared with $r\approx0.2$ for other groups). This appears to be related at least in part to the robustness of the mastoid processes, which are relatively small in the 'probables.' This may indicate that mastoid process robustness is diminished in relatively broad crania, possibly because there is less leverage during extension and flexion. The feature may simply be a statistical anomaly from examining a large number of possible variables.

Euclidian cluster analysis based on cranial length and breadth was performed using SPSS16.0 and the overall results (Figure 59) clearly illustrate sexual dimorphism, supporting the intuitive interpretation of the scatter diagram for sex.

Excluding the outlier IS(2781), there are five clusters that divide into two groups (Figure 59). A male (1a) and a female (1b) cluster combine and group together, with a second female cluster (1c) that is predominantly 'probables.' Males (2b) and probable males (2a) group together but form separate clusters.

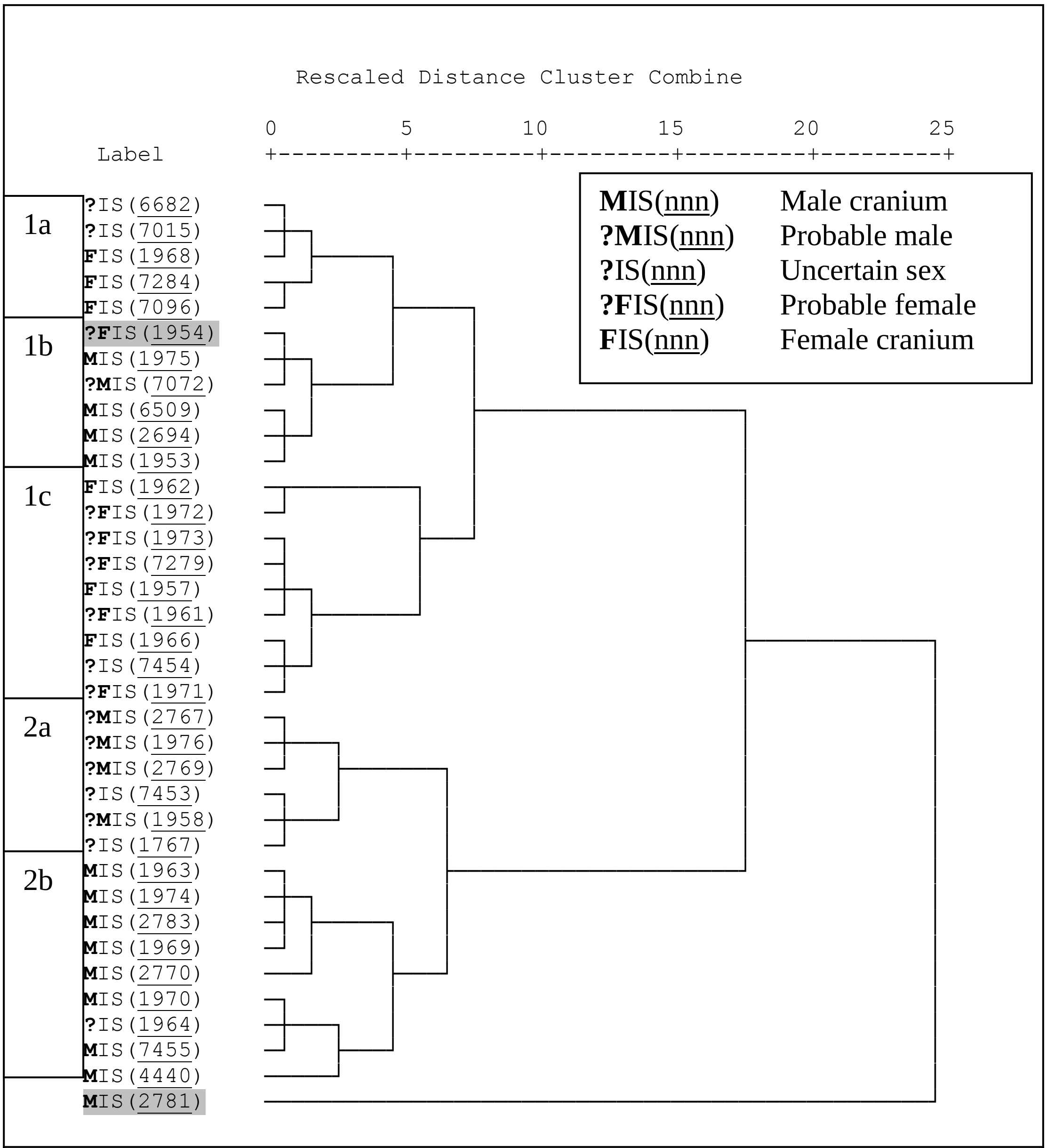


Figure 59. Clustering of crania by length and breadth only.

IS(1954) (shaded in Figure above) is the only individual that appears to cluster inappropriately for sex. When cranial height is included in the analysis, IS(1954) clusters with females. IS(2781) (shaded above) is a distinct outlier. Interestingly, male group 1b lies on the otherwise female side of the distribution. There is no indication of any division according to location in the tomb related to these groups.

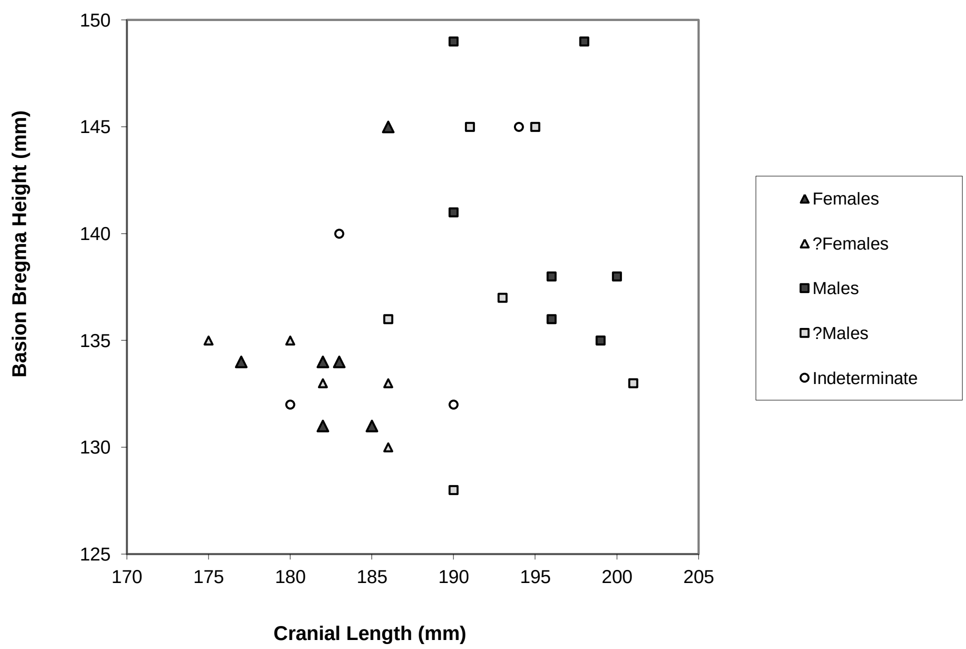


Figure 60. Relationships of adult cranial breadth and height to sex.

Cranial height contributes to separation of the sexes metrically without exhibiting any obvious direct relationship to cranial length (Figure 60). There may be some negative correlation between the two for females but not males. Increasing the number of dimensions examined reduced sample size: three dimensions could only be measured for 28 adult crania. Many standard measurements were only possible in very few cases, though all were examined. Interorbital breadth and nasal breadth exhibited no apparent sexual dimorphism. The dimensions of the foramen magnum and maxillo-alveolar length for example overlapped significantly for the sexes and only the very largest male examples could be separated. Cluster analysis was therefore not expected to be useful with more than three dimensions (Figures 59, 61).

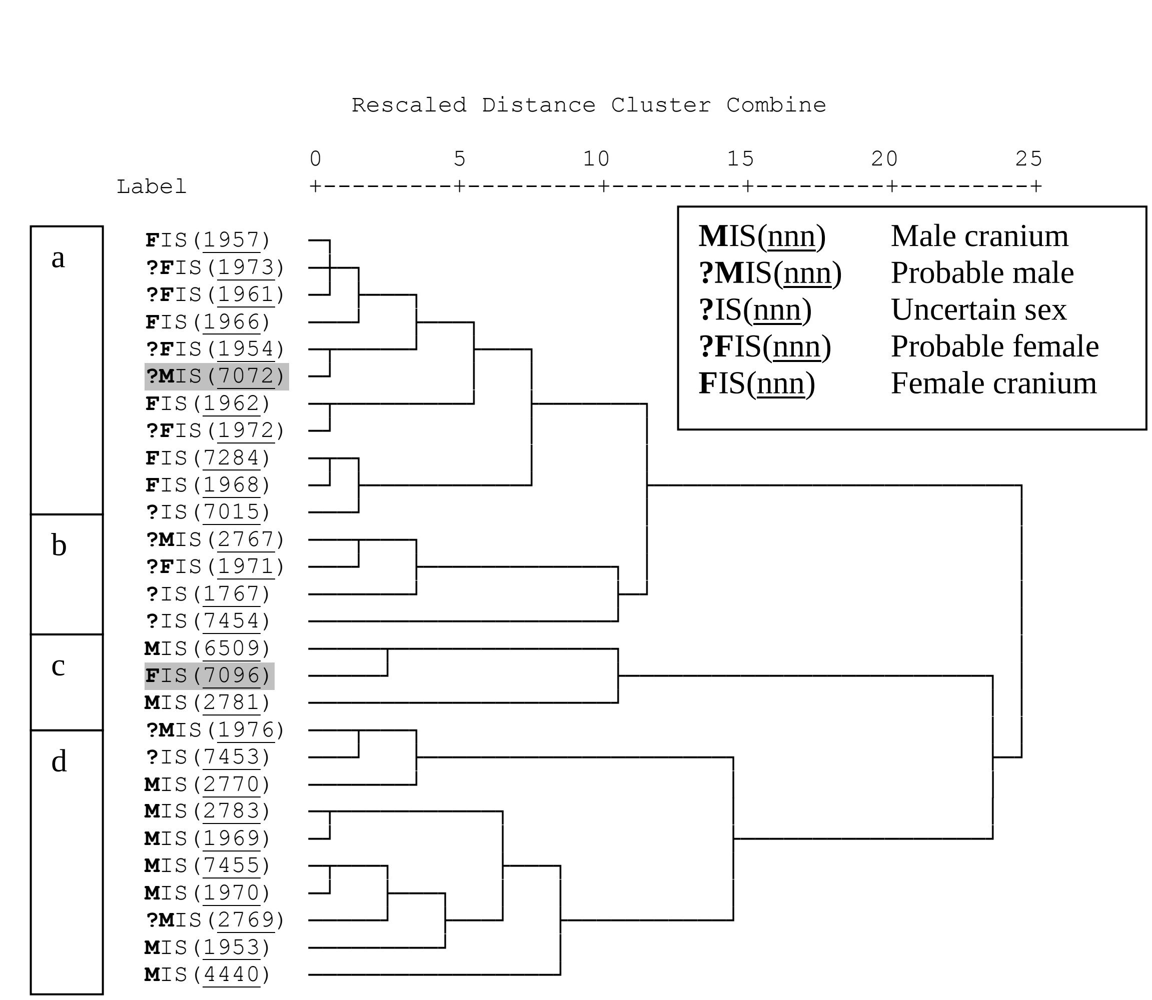


Figure 61. Results of three-dimensional craniometric cluster analysis.

The three dimensional cluster analysis (Figure 61) places the uncertainly sexed individuals (the 'probables' and indeterminate crania) as a distinct cluster in the otherwise female part of the distribution. The crania that appear to cluster inappropriately (Table 83, shaded) - IS(7096) and IS(7072) - were both highly fragmented, which may have contributed to errors of measurement. IS(1954) and IS(2781) cluster appropriately here.

Table 83. Correlation between Sex and (3-D) Craniometric Clusters.

Cluster	M	?M	?	?F	F
Female region (a)	0	1	1	4	5
Uncertain (b)	0	1	2	1	0
Male (c)	2	0	0	0	1
Male (d)	7	2	1	0	0

Sexual Dimorphism of Permanent Maxillary Teeth

Attempts to define sexual dimorphism in the teeth were inhibited by the large proportion that were loose and could not be attributed to any mandible or cranium. Where sex could be attributed from morphology of cranium or mandible, the sample sizes for the anterior teeth (incisors through premolars) were too small to examine sexual dimorphism. Significant sample sizes were observable for first and second molars. Third molars were considered to be unreliable and, though recorded, were not examined for sexual dimorphism. It was found that a large measurement of one molar was usually accommodated by a small size of that adjacent.

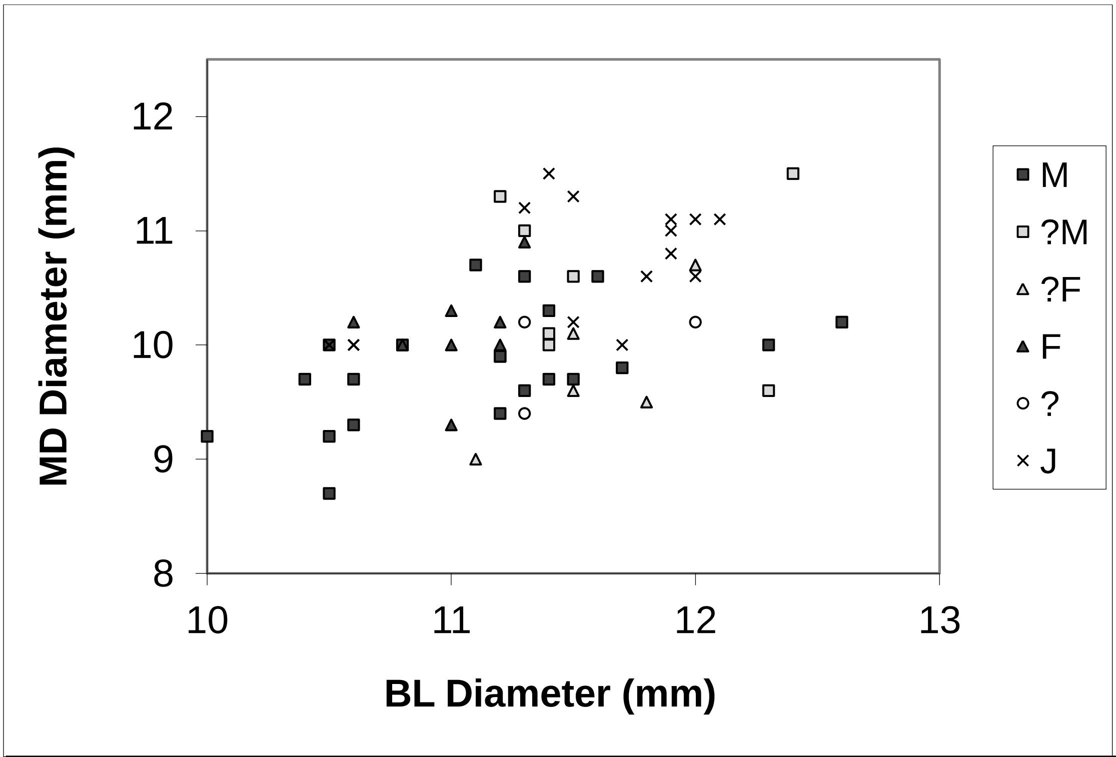


Figure 62. Pooled first molar diameters and sex
(one tooth per cranium, usually right).

Juveniles and uncertainly sexed adult males appear to have larger first molar crowns than confidently sexed adults (Figure 62), which may imply the presence of some condition that contraindicates survival.

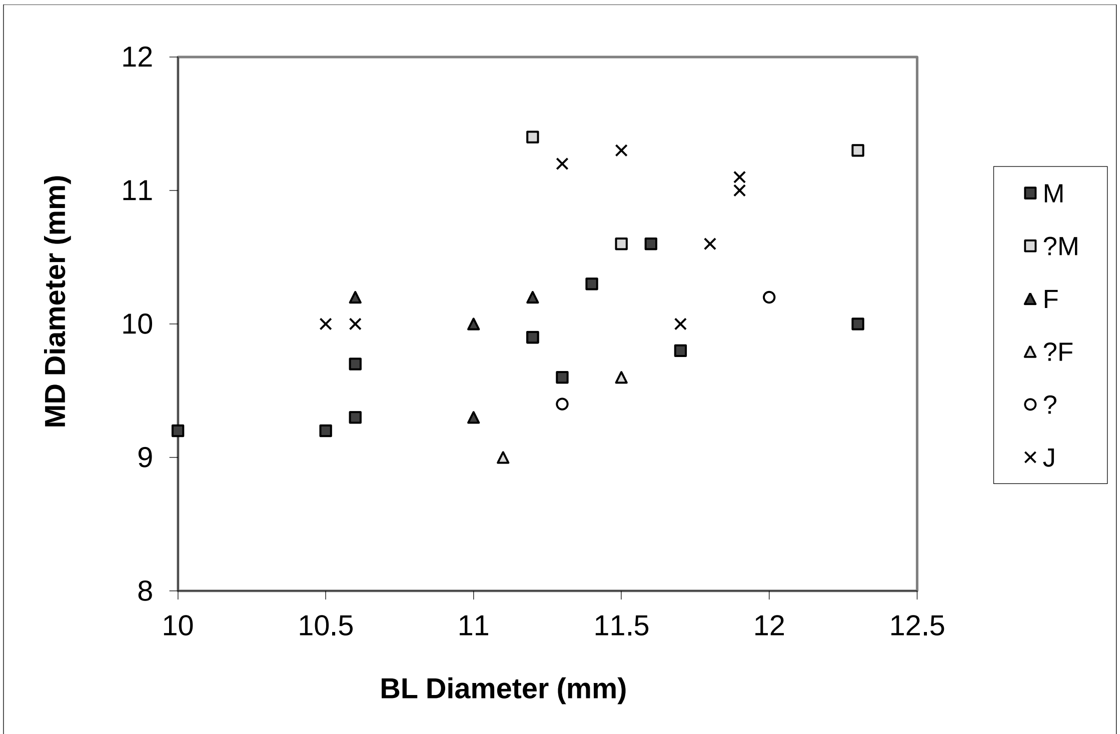


Figure 63. Right first molar dimensions and sex.

There were 30 paired left and right first molars (including juveniles), which were compared for size. The right side averaged very slightly smaller but the difference was statistically insignificant.

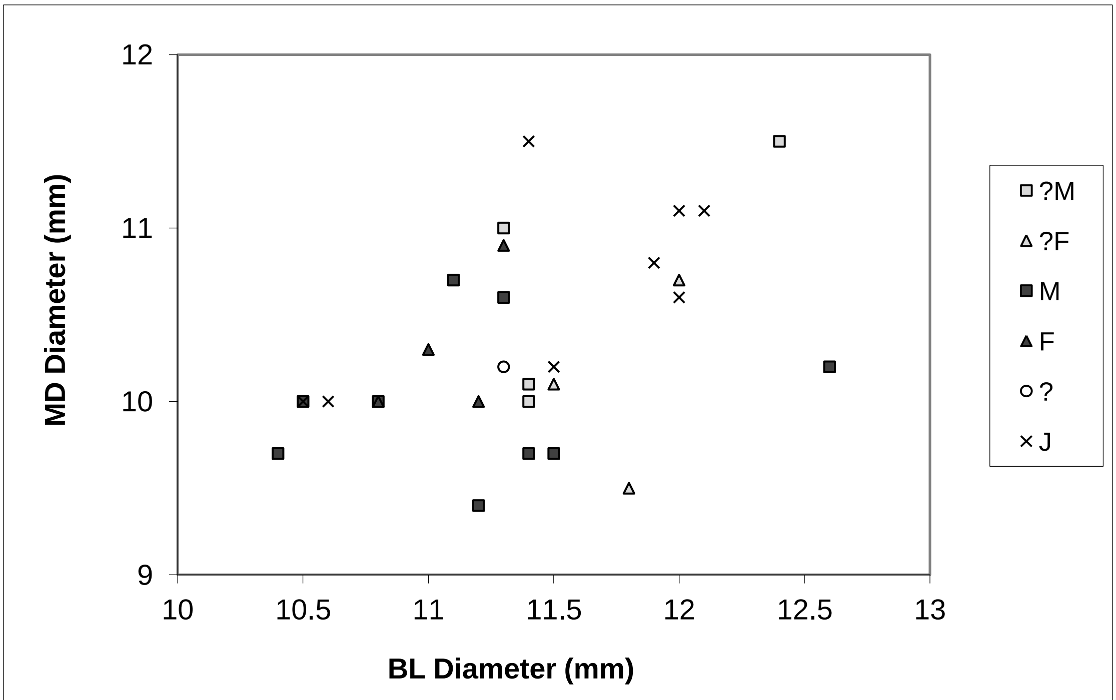


Figure 64. Left first molars and sex.

Table 84. T-Test Results Comparing M1 Area Between Groups.						
Normalised Area	F	?F	M	?M	J	?
F						
?F	*t*=1.052; p=0.15					
M	*t*=0.836; p=0.20	***t*=1.625; p=0.05**				
?M	*t*=1.226; p=0.12	***t*=1.764; p=0.05**	*t*=0.637; p=0.26			
J	***t*=3.070; p<0.01**	***t*=3.654; p<0.01**	***t*=1.912; p=0.03**	*t*=0.724; p=0.24		
?	***t*=1.554; p=0.06**	***t*=2.255; p=0.02**	*t*=0.652; p=0.26	*t*=0.156; p=0.44	*t*=1.199; p=0.12	

NB. *t* values rounded to 3 decimal places; probability estimates to 2 decimal places; Tooth area estimated from the products of BL and MD measurements normalised by the overall means; degrees of freedom vary for each calculation; tests are 1-tailed and were simultaneously run assuming equal and different sample variances, with negligible differences at this level of measurement. p<0.1 shown in bold.

Sexual dimorphism in tooth crowns is small and the sexes overlap significantly (e.g. Harris 2008:46-7). Testing group dimension distributions using Student's *t* (Tables 84, 85) suggested that the juveniles and 'probable females' were not entirely consistent with other groups there is a significant probability that other pairs of groups are from the same or similar populations. The difference is particularly exhibited in mesiodistal breadth but is also present at a lower probability in bucco-lingual breadth, suggesting that tooth crown bulk is affected. The indeterminately sexed crania had teeth consistent with the males but not with females. The juveniles seem to be possibly consistent with 'probable males' but are distinguished by MD diameter; the 'probable males' are themselves consistent with 'males.' The 'probable females' have sufficient similarities with the 'females' to infer that the two are the same group. The males and females appear to be consistent with a single group.

Table 85. T-Test Results Comparing M1 Dimensions Between Groups.						
BL \ MD	F	?F	M	?M	J	?
F		***t*=1.942; p=0.04**	*t*=0.163; p=0.44	*t*=0.833; p=0.20	***t*=3.031; p<0.01**	*t*=0.196; p=0.42
?F	*t*=0.995; p=0.16		***t*=1.921; p=0.03**	***t*=2.416; p=0.02**	***t*=4.236; p<0.01**	***t*=1.829; p=0.04**
M	*t*=1.263; p=0.10	*t*=0.107; p=0.45		*t*=0.614; p=0.27	***t*=2.536; p<0.01**	*t*=0.045; p=0.48
?M	*t*=1.278; p=0.11	*t*=0.646; p=0.27	*t*=0.602; p=0.27		***t*=1.788; p<0.01**	*t*=0.522; p=0.30
J	***t*=1.916; p=0.03**	*t*=0.783; p=0.22	*t*=0.746; p=0.23	*t*=0.129; p=0.45		***t*=2.252; p=0.02**
?	***t*=2.808; p<0.01**	***t*=1.410; p=0.09**	***t*=1.441; p=0.08**	*t*=0.232; p=0.41	*t*=0.571; p=0.28	
NB. *t* values rounded to 3 decimal places; probability estimates to 2 decimal places; tests are 1-tailed and were simultaneously run assuming equal and different sample variances, with negligible differences at this level of measurement; degrees of freedom vary for each calculation; teeth from both sides were pooled.						

The second molar crown dimensions exhibit some similar features but not clearly. The larger male teeth appear to be distinct from the females (distinguished by area, especially BL diameter) but the cluster overlaps with the juveniles. As with the first molars, the indeterminately sexed crania tend to possess large teeth and seem likely to be from males (Figure 65). The slightly different patterns of BL and MD diameter dimorphism may reflect the different time of final size determination during development (Kieser 1990:86-7), although the underlying mechanism is uncertain and accommodation for size by adjacent teeth, as observed, might contradict this.

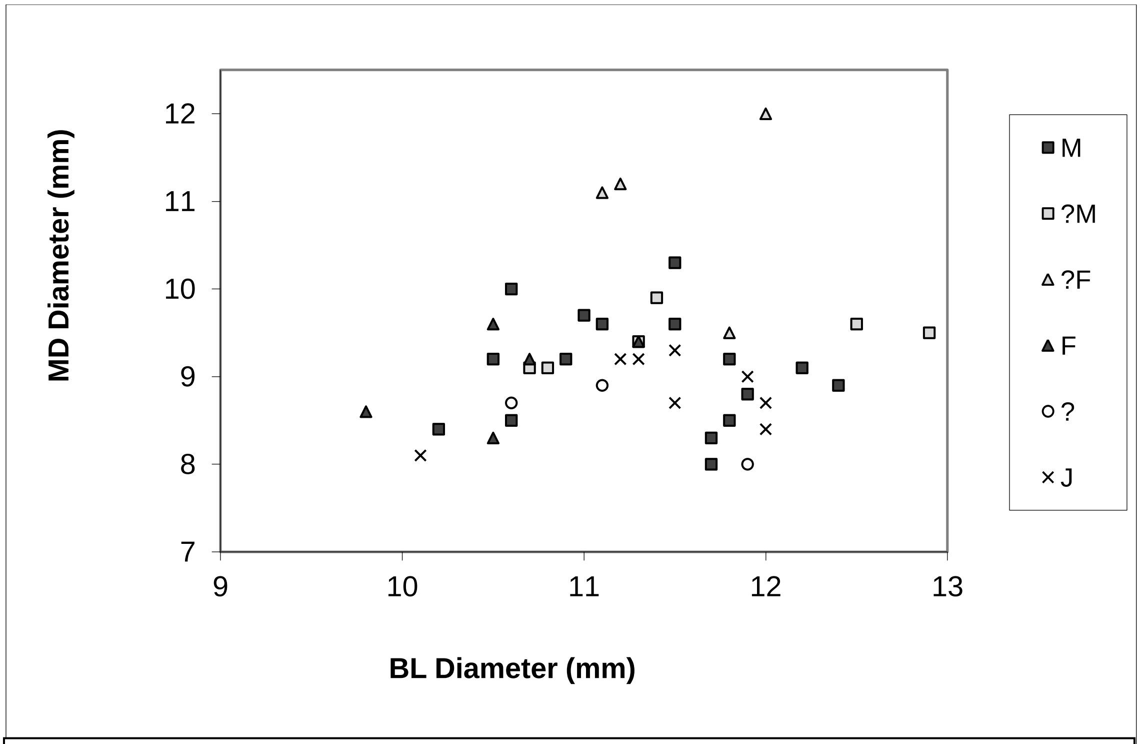


Figure 65. Pooled second molar diameters and sex.

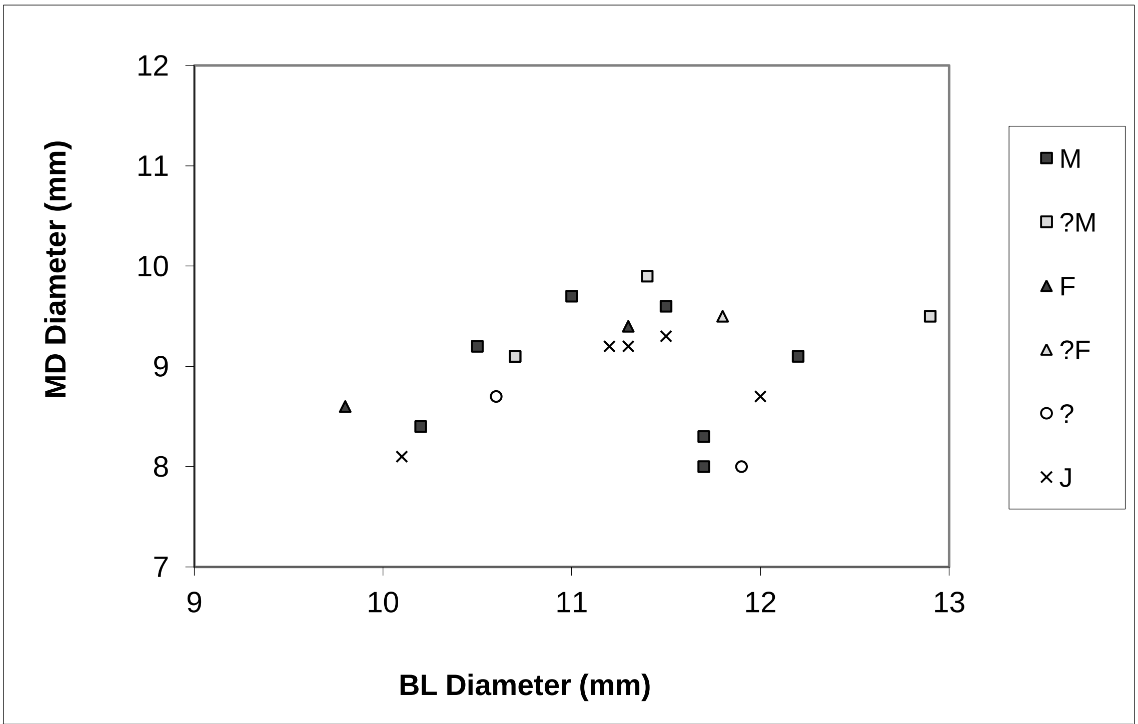


Figure 66. Right second molar crown dimensions and sex.

There were 14 paired left and right second molars (including juveniles), which were examined for relative sizes. The right side averaged slightly smaller than the left in both dimensions but the difference was negligible.

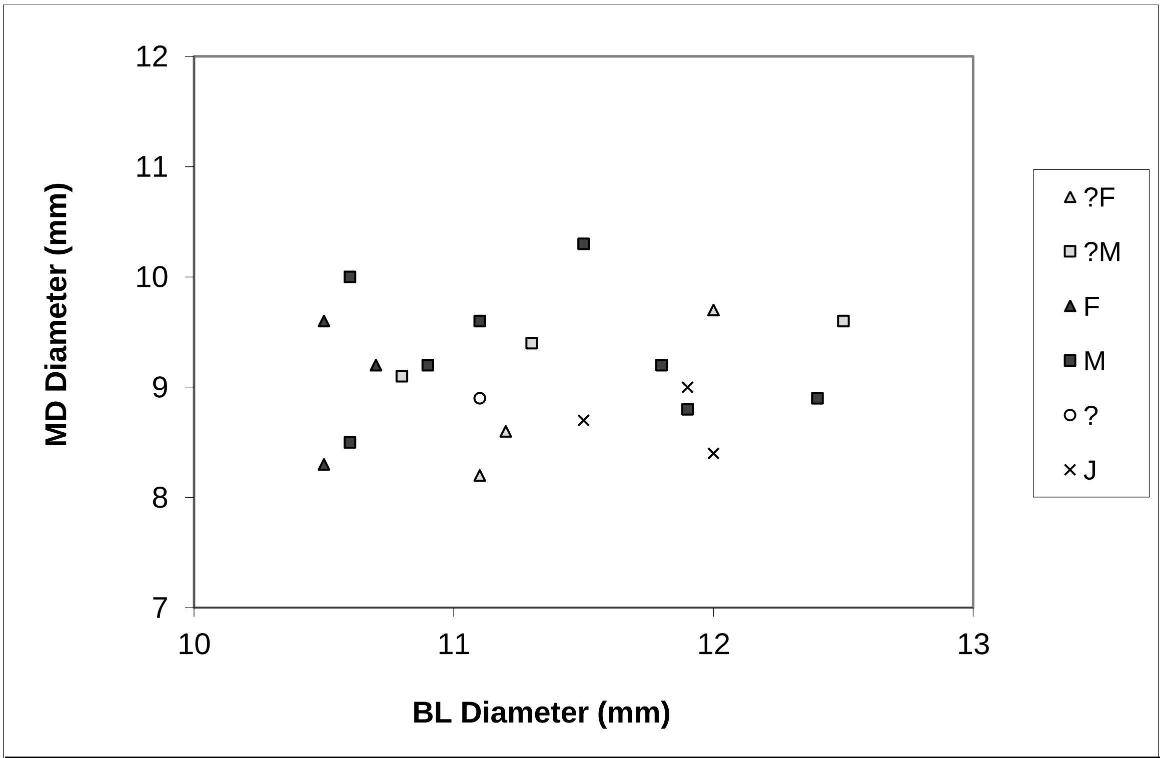


Figure 67. Left second molar dimensions.

Table 86. T-Test Results Comparing M2 Normalised Area Estimates Between Groups.

Normalised Area	F	?F	M	?M	J	?
F						
?F	*t*=1.293; p=0.23					
M	***t*=2.404; p=0.02**	***t*=3.208; p~0**				
?M	*t*=1.616; p=0.13	***t*=2.632; p=0.03**	*t*=1.231; p=0.23			
J	-	-	-	-		
?	*t*=1.654; p=0.12	***t*=2.623; p=0.02**	*t*=0.784; p=0.44	*t*=0.310; p=0.76	-	

NB. *t* values rounded to 3 decimal places; probability estimates to 2 decimal places; Tooth area estimated from the products of BL and MD measurements normalised by the overall means; degrees of freedom vary for each calculation; tests are 2-tailed and were simultaneously run assuming equal and different sample variances, with negligible differences in the results. p values under 0.1 are shown in bold.

Table 87. T-Test Results Comparing M2 Dimensions Between Groups.						
BL \ MD	F	?F	M	?M	J	?
F		***t*=3.220; p=0.01**	*t*=0.688; p=0.50	*t*=0.134; p=0.90	-	*t*=0.347; p=0.73
?F	*t*=0.241; p=0.82		***t*=4.211; p~0**	***t*=2.054; p=0.07**	-	***t*=2.703; p=0.02**
M	***t*=2.924; p=0.01**	***t*=1.884; p=0.07**		*t*=0.586; p=0.56	-	*t*=1.021; p=0.32
?M	***t*=2.434; p=0.03**	*t*=1.514; p=0.17	*t*=0.575; p=0.57		-	*t*=0.112; p=0.91
J	-	-	-	-		-
?	***t*=3.061; p=0.01**	***t*=1.883; p=0.08**	*t*=0.132; p=0.90	*t*=0.504; p=0.62	-	
NB. *t* values rounded to 3 decimal places; probability estimates to 2 decimal places; tests are 1-tailed and were simultaneously run assuming equal and different sample variances, with negligible differences at this level of measurement; degrees of freedom vary for each calculation; teeth from both sides were pooled. p values below 0.1 are shown in bold						

There seem to be sex-related differences in tooth size. There may be some relationship with cranial dimensions or wear but these results suggest the presence of sexual dimorphism in the molars. The distinction between more and less confidently sexed males apparently exhibited by molar size cannot be sustained statistically but the juvenile distribution might nonetheless imply some euploid syndrome related to Klinefelter's such as 47XYY, in which males with an extra chromosome develop abnormally and with large molars (e.g. Alvesalo *et al.* 1975; Alvesalo and Polton 1983; Townsend 2003), although the opposite observation has also been made (Sćepan *et al*. 1993) and the anterior teeth tend to be relatively small. The presence of the amelogenin gene on the sex chromosomes makes some such aetiology possible. It is likely that male juveniles were more likely to be interred in the tomb than females but the first molar sizes imply that there was some further factor involved.

Sexual Dimorphism of Other Skeletal Elements

Metric and morphological analyses of longbones for sex attribution were also attempted. Vertical head and neck diameters and bicondylar breadth of femur and vertical head diameter and distal morphology of the humerus were examined (Stewart 1979; Rogers 1999) as these variables were observable as relatively large samples.

Table 88. Sex Attribution from Adult Femoral Head Diameter (following Stewart 1979:120).

	Female <42.5mm	Probably Female 42.5-43.5mm	Indeterminate 43.5-46.5mm	Probably Male 46.5-47.5mm	Male >47.5mm
All adult	22	8	49	17	14
Left only	12	2	15	5	7
Right only	7	6	21	10	3

The femoral head results suggest presence of equal numbers of each sex but the number scored as indeterminate is large (Table 88 above). The results seem to display a bimodal distribution (Figure 68, p218 below). If the combined figures for all femoral heads are considered, then the sex distributions appear to be skewed, with generally smaller sizes than expected. The female mean is expected to be at around 43mm and the male around 48mm (Stewart 1979:Fig.34). This suggests that the categories defined by Stewart for sex assessment from femoral head diameter may be inappropriate to this sample and could explain why these results do not agree with other sex assessment methods.

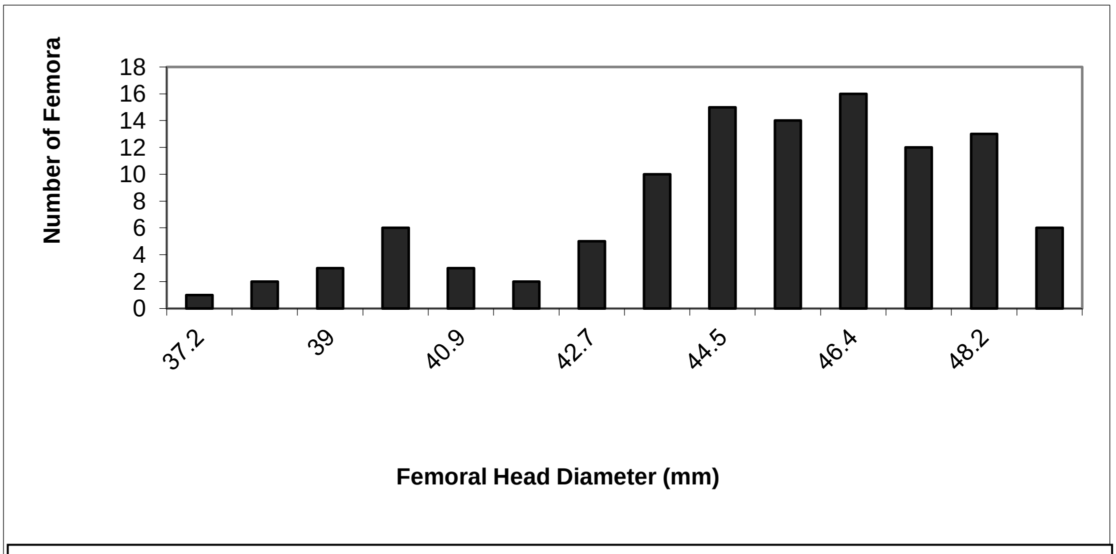


Figure 68. Distribution of adult femoral head diameters from Isbister.
(The frequency distribution illustrated by Stewart (1979:121) shows sizes overlap so that the limit of each sex occurs near to the mean of the other.)

The femoral neck diameter is another indicator of sex but dimorphism varies with population, so reliability for an unknown sample is uncertain (Seidemann *et al.* 1998). This dimension exhibits secular drift in females after 1900 (Stojanowski and Seidemann 1999), which suggests that body mass or stature are causally related and may infer that access to nutrition, activity or stresses might affect the Isbister population. The method was expected to be useful because femoral neck fragments often survived in a measurable condition.

The published discrimination function is relatively inaccurate, estimated at 83% for Caucasians (Seidemann *et al.* 1998). Femoral neck measurements clearly indicate sexual dimorphism (Seidemann *et al.* 1998: fig. 2) but it may be more appropriate to use a five-point attribution. An estimation (Table 89 below) was adopted following visual inspection of the published data.

Table 89. Sex Attribution from Adult Femoral Neck Diameter.					
	Female	**Probably Female**	**Indeterminate**	**Probably Male**	**Male**
Measurement	<29.2mm	-	29.2-30.5mm	30.6-32mm	>32mm
MNI	11	-	7	14	21
All adult	13	-	13	24	42
Left side only	11	-	5	8	20
Right side only	2	-	7	14	20
NB. No 'probably female' group could be identified.					

Even if the indeterminate femora were female, these estimates suggest that males outnumbered females by more than 2:1, possibly by 3:1, but this lacks adequate verification. An approximated distinction was used to compare a prehistoric sample with modern data in which there is a demonstrated secular trend. It is not unlikely that the Isbister sample included a number of females with large measurements, which could explain such an extreme result.

The correlation between femoral head diameter and femoral neck diameter was examined. Overall, there is close agreement between the values, r=0.802. Because of concern regarding activity-related effects that might occur through agricultural, nautical or hunting activities, the sides were also examined separately. The left femora correlate particularly closely: r=0.899. The right femora exhibited a lower correlation: r=0.706.

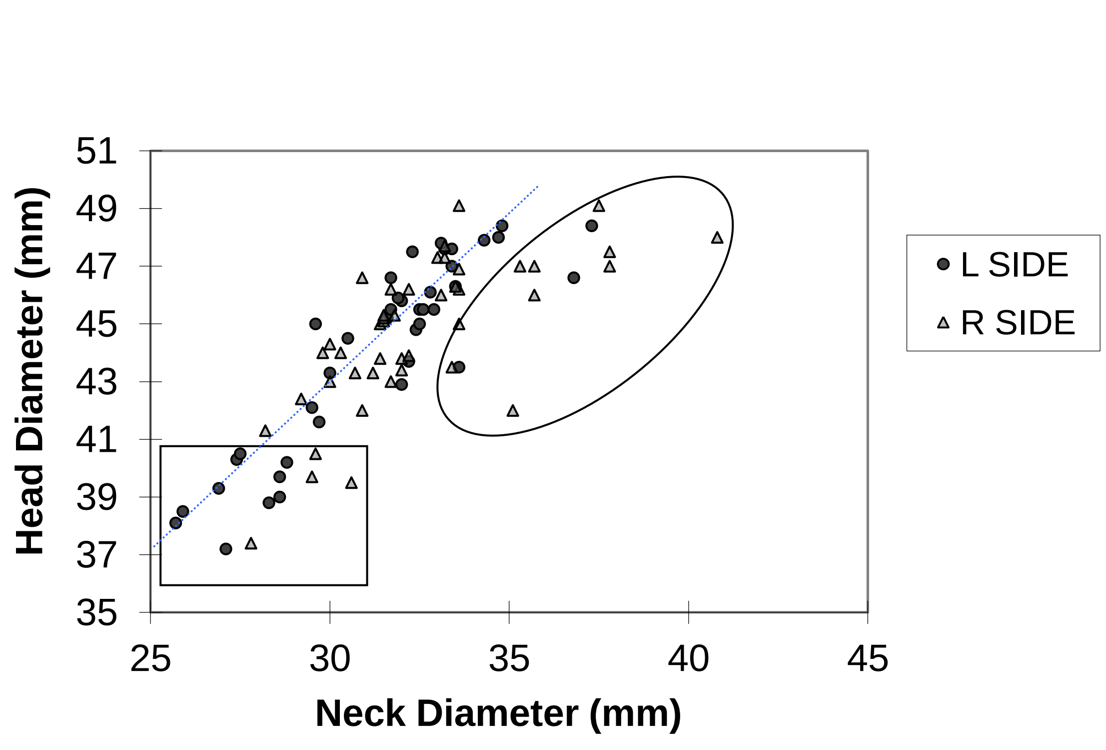


Figure 69. Proximal femur measurements from Isbister adults.

Note the tendency of right femora to deviate from the expected proportions (marked).

There is a deviation of the right side examples away from the regression line with a greater neck diameter than would have been predicted from the head size (Figure 69: dotted line above indicates regression left side y on x). The difference is generally towards a relatively more robust neck diameter on the right side (indicated by ellipse and rectangle above). This suggests that robustness is related to side and is likely to relate to greater mechanical forces affecting the right femur. The means of the left and right femoral necks are significantly different, although the head diameter means of the two sides are very similar. Testing the assumption that the sides were identical, it was found that the difference in femoral neck diameter is significant at the 95% confidence level.

Table 90. Statistical Differences Between Left and Right Proximal Femora Dimensions.				
	Vertical head diameter		**Neck diameter**	
Side	**Left**	**Right**	**Left**	**Right**
Mean	44.07	44.69	31.33	32.48
Variance	11.038	6.719	7.384	7.172
N	40	44	44	44
F (H_0: $\sigma_1^2=\sigma_2^2$)	F=1.643; p=0.0569		F=1.029; p=0.4623	
t (H_0: $\mu_1=\mu_2$)	t=0.947; p=0.35		t=1.999; p=0.05	
The mean neck diameter and head diameter variance differences between the sides are statistically significant but the mean head diameter size is not.				

It was noted that the bicondylar breadths displayed a tendency for dimorphism that might give considerable confidence to the sex attributions that were possible. In the case of these observations, it is noticeable that the female distribution is skewed downwards, as with the head diameters. The male region bicondylar breadth distribution is skewed upwards, which is opposite to the implication inferred from the femoral heads and suggests that this may be the result of activity-related, metabolic or genetic features.

Table 91. Sex Attribution from Adult Femoral Bicondylar Breadths (following Krogman and Íşcan 1986:236).					
	Female <72 mm	**Probably Female 72-4mm**	**Indeterminate 74-6mm**	**Probably Male 76-8mm**	**Male >78mm**
All adult	16	6	5	8	31
Left side	8	5	2	3	13
Right side	8	1	3	5	18

As with the femora, humeral head diameter suggests a more equal number of each sex than indicated by distal morphology of the bone. The number of female attributions is similar in both methods but head diameters had fewer male or probable male observations: there is no obvious explanation for greater fragmentation of male femoral heads.

Table 92. Sex Attribution from Adult Humerus Head Diameter (after Stewart 1979:100-1).					
Attribution	**Female**	**Probably Female**	**Indeterminate**	**Probably Male**	**Male**
mm	<43	43-4	44-6	46-7	>47
All adult	19	2	9	7	23
Left side	11	1	7	3	3
Right side	8	1	2	4	20

Table 93. Sex Attribution from Adult Distal Humerus Morphology (after Rogers 1999).					
	Female	**Probably Female**	**Indeterminate**	**Probably Male**	**Male**
All adult	13	8	40	19	16
Left side	6	2	21	11	7
Right side	7	6	19	8	9

Sex attribution from the distal humerus morphology (after Rogers 1999) was problematic because many elements exhibited characteristics of both sexes, whilst fragmentation inhibited adequate observation of some features. Sex was attributed when all characters were the same or when three were for that sex and one was indeterminate; probable sex was attributed where three characteristics were for that sex but one was opposite or where two characteristics were for that sex and two were indeterminate; other score patterns were considered indeterminate.

Table 94. Female and Male Attributions from Different Elements.			
Observation	**All Females**	**All Males**	**Ratio F:M**
Femoral head diameter	30	31	1:1
Humeral head diameter	21	30	1:1.4
Femoral bicondylar breadth	22	39	1:1.8
Distal humerus morphology	21	35	1:1.7
Cranial morphology	15	28	1:1.9

Comparing the sex ratios indicated by different observations suggests a preponderance of males over females. Since cranial attributions appear likely to be correct, approximately two adult males per female were probably interred in Isbister tomb. The difference in numbers attributed to each sex from using different elements has several possible explanations:

- Female crania were more fragmented and thus incapable of being properly examined, resulting by default in a predominantly male attribution for an evenly distributed sample. The opposite was inferred above, so this possibility may be ignored.
- Developmental abnormalities and pathological conditions may have affected the post-cranial elements of a large proportion of individuals, causing stunted development and therefore erroneous female attribution in a predominantly male sample.
- Physical labour may have resulted in greater robusticity of females, which may have led to erroneous attributions as male.
- The population had more males than females.
- The females died more often as juveniles.
- Males were more likely to receive interment.

Minimum Number of Individuals (MNI)

“Unfortunately, some archaeologists are mis-using age data particularly from neolithic sites in the Orkneys; and despite the warnings of the experts concerned, unreliable conclusions are being drawn about the demographic structure of neolithic Orkney.”

Andrew Selkirk 1987:287

The minimum number of individuals (MNI) interred in each tomb was estimated formally by examining the number of distinct skeletal elements present in the assemblage, considering age and sex distribution. The numbers of postcranial elements were consistent with a demographic assessment based on the crania.

The existence of 85 individuals at Isbister can be directly demonstrated through the presence of unique (not duplicated) cranial elements. Most were in the Orkney Museum collection. There is one neonate, indicated by the presence of long-bones at OM for which a consistent cranial fragment was identified at NMS. Of three crania at the Tomb of the Eagles Visitor Centre, one has fragments included in the OM collection). One cranium was loaned to Maria Vanezis for her computer-generated facial reconstruction and could not be located, one was destroyed in radiocarbon dating and one was given away by Mr. Simison and lost in a house fire but it is possible that elements of these survive in the collections: the dated cranium for example was described as separate fragments before preparation (Chesterman 1978:vol.1, March 11).

It is immediately apparent that the numbers do not reflect the 341 individuals reported (Hedges 1983). The number of individuals in each age category is lower than reported and used as the basis for demographic analyses (Hedges 1982). The suggested peak in mortality between 20 and 24 years of age (Hedges 1983:274-5) cannot be supported, neither can the supposed rarity of deaths at age over 30. Hedges claimed a weighted 18 (14.66 individuals) died below the age of one year (49‰ of the population) but in fact only a single mandible out of 82 was attributable to this age group, although there is skeletal evidence of another neonate. 24 individuals were claimed for the under two year age group (Hedges 1983:274-5) but only seven mandibles (and three maxillae) exist. The numbers in each age range are summarised in Table 95 below.

The ratios between successive juvenile age groups agree reasonably well with the distribution suggested by Hedges. There is a difference in the oldest juvenile groups because Chesterman, apparently misreading his own notes, attributed ages with greater precision than could be justified and assumed that remains in different areas of the tomb came from different individuals (Chesterman 1983; Chesterman 1978).

A pre-modern mortality curve (e.g. Weiss 1973:26-30; Scott and Duncan 2002:160-194; Séguy *et al*. 2008) would be expected to show *c*15-25% infants dying, which was not found in Isbister tomb. Only one mandible fell into the below one year age group (estimated at 9±3 months). There are long-bones that are more consistent with an infant dying at about three months of age but this may be due to severe growth retardation. Only twelve mandibles were aged below four years at death. The age at death of juveniles in the sample peaked at about four to seven years. This seems unlikely to reflect population mortality but, notwithstanding a tendency for infant underrepresentation archaeologically (e.g. Acsádi and Nemeskéri 1970), suggests some pattern of selection for interment in the tomb (e.g. Hassan 1981:96). Mandibles appear to have survived well in the tomb and have a high probability of being collected during excavation so it is assumed that this age distribution reflects the numbers interred. Casual disposal of young infants may have been a common practice but begs the question of why some were deposited in the tomb. The juvenile mandibles were found to fall in equal numbers to each of the sexes, with a similar number being indeterminate. This may however simply reflect the poor resolution of the method, especially since juvenile maxillary permanent molar sizes observed seem inconsistent with the adult female measurements.

It is possible that there was a particularly high mortality rate between the ages of about four and seven years. This might have been due to cultural or biological factors. It was noted that some of the juvenile crania displayed signs of perimortem trauma, suggestive of a violent death. Four years old would seem to be rather advanced an age for infanticide unless it related to particular factors such as a failure to successfully pass a rite of passage, or child sacrifice. This apparent peak in mortality may result from a combination of younger individuals being interred elsewhere and the older age group possibly dying elsewhere. It seems more likely to reflect increased vulnerability from the age of four years, perhaps related to weaning or increasing exposure to danger.

<table>
<tr><td colspan="15">Table 95. Mortality Ratios in Successive Juvenile Age Groups Demonstrable from the Isbister Remains.</td></tr>
<tr><th colspan="2">Age at death (yrs)</th><th>0-1</th><th>1-2</th><th>2-3</th><th>3-4</th><th>4-5</th><th>5-6</th><th>6-7</th><th>7-8</th><th>8-9</th><th>9-10</th><th>10-11</th><th>11-12</th><th>12-13</th></tr>
<tr><td rowspan="3">Hedges 1983</td><td>Number Claimed</td><td>16.76</td><td>7.24</td><td>4.52</td><td>8.19</td><td>8.56</td><td>11.19</td><td>17.58</td><td>2.82</td><td>4.88</td><td>4.52</td><td>3.56</td><td>1.13</td><td>3</td></tr>
<tr><td>Running Total</td><td>16.76</td><td>24</td><td>28.52</td><td>36.71</td><td>45.27</td><td>56.46</td><td>74.04</td><td>76.86</td><td>81.74</td><td>86.26</td><td>89.82</td><td>90.95</td><td>93.95</td></tr>
<tr><td>Ratio to Previous</td><td colspan="2">-</td><td colspan="2">1.5</td><td colspan="3">2</td><td colspan="3">1.2</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td rowspan="3">This study</td><td>Number Observed</td><td>1</td><td>6</td><td colspan="2">5</td><td colspan="3">9</td><td colspan="3">5</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Running Total</td><td>1</td><td>7</td><td>10</td><td>12</td><td>14</td><td>18</td><td>21</td><td>24</td><td>26</td><td>26</td><td>26</td><td>26</td><td>26</td></tr>
<tr><td>Ratio to Previous</td><td colspan="2">-</td><td colspan="2">1.7</td><td colspan="3">1.8</td><td colspan="3">1.2</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Stature and Proportions

Size calculations from the Isbister collection were problematic because of damage. Longbones rarely survived sufficiently complete to measure and in many cases it was also impossible to apply the estimates of Steele (Steele and Bramblett 1988:165-71, 229-36). Only four femora could be measured for length, although 15 measurements are listed in Chesterman's manuscript notes. Chesterman's measurements were therefore used to calculate stature (Trotter and Gleser 1952; Trotter 1970) and compared with measurements possible now. Calculations were made from all longbone lengths assuming each sex but only the more likely sex is noted below. It was recognised that Chesterman had been able to measure more bones but unexpectedly, a small number of bones measured in this project were not consistent with any in Chesterman's MS. A small number had also been listed as "missing" in Lorimer's annotations to the MS but appear to be consistent with elements that had been labelled.

Equations derived for estimating stature were derived from modern samples and may not be appropriate to a Neolithic Orcadian population. Those of Pearson may be considered most appropriate if it is assumed that the nineteenth century British data that he used are more likely to represent the proportions of Neolithic Orcadians than those of the 20th century Americans studied by Trotter and Gleser. The equations of Trotter (Trotter 1970; Trotter and Gleser 1952) were selected because they are the most commonly quoted and are therefore the best to use for most comparative purposes, the results from the Pearson equations are also given. The formulae of Trotter (1970), Trotter and Gleser (1952) and Wilson (2010), and the tables of Manouvrier

(Krogman 1962) give results that all agree closely; the formulae of Pearson (1899) return stature values that are consistently smaller. This may be due to factors present in the different samples used but is perhaps more likely to be methodological, depending on the quality of source material (Stewart 1979:194ff). There is nonetheless a particular problem with the use of the tibia under the Trotter and Gleser method because there may be an error in the description of the measurement as including the medial malleolus, which may lead to slightly larger stature estimates for this bone (Jantz *et al*. 1995). A correction could be applied to account for shrinking with age: no such correction has been applied because this seems superfluous outside forensic contexts.

Although the sample numbers are small and subject to statistical errors, the average adult male height was probably about 5’6” and females about 4’11”. A maximum stature of 5’10” for males and a minimum of 4’9” for females seem likely. The female maximum and male minimum are more difficult to assess because size was used in attributing sex but the two groups are likely to overlap at around 5’2” – 5’3”.

The female stature means are quite consistent across elements and also between calculations, suggesting that the adult female mean stature estimate of about 4'11" is likely to be robust. Male stature estimates are slightly more variable than female, which may imply some additional influence.

Table 96. Mean Values for Adult Stature at Isbister from Different Bones (cm).				
	Trotter (1970)		**Pearson (1899)**	
	Male	**Female**	**Male**	**Female**
Femur R **Femur L**	165.4 ±3.7 (n=3) 164.6 ±4.2 (5)	146.8 ±3.7(n=4) 150.7 ±4.8 (3)	165.0 165.0	147.1 148.9
Femur mean	**164.9** **= 5'5"**	**148.5** **= 4'10"**	**165.0** **= 5'5"**	**148.0** **= 4'10"**
Tibia R **Tibia L**	170.5± 6.7 (5) 168.8 ±8.2 (3)	151.6 ±1.7 (3) 150.0 (1)	165.3 162.1	147.8 146.5
Tibia mean	**169.9** **= 5'7"**	**151.2** **= 4'11"**	**164.1** **= 5'5"**	**147.5** **= 4'10"**
Fibula L		148.7 (n=1), 4'10"		
Humerus R **Humerus L**	168.1 ±4.0 (9) 170.0 ±6.0 (4)	166.2 (1) 150.1 ±3.2 (5)	162.2 164.0	160.2 146.3
Humerus mean	**168.6** **= 5'6"**	**152.8** **= 4'11"**	**162.8** **= 5'4"**	**149.0** **= 4'11"**
Radius R **Radius L**	171.2 (2) 178.1 (1)	153.1 (1) 152.6 (1)	165.7 171.6	150.4 150.1
Radius mean	**173.5** **= 5'8"**	**152.8** **= 5'**	**167.7** **= 5'6"**	**150.3** **= 4'11"**

Major Indices

Meric index: the relationship between anteroposterior and mediolateral diameters of the femoral superior diaphysis.

Table 97. Number of Left and Right Femora from Isbister in Different Meric Classes.				
	Definition	**Left**	**Right**	**Total**
Platymeric	I≤84.9	15	17	32
Eurymeric	85<I<99.9	1	0	1
Stenomeric	I≥100	0	0	0
Mean values		73.01±6.64	70.32±4.10	71.63±5.56

Because sex could be attributed to the femora, the meric index values were examined for both sex and side variations that might indicate activity patterns.

Table 98. Sex Distribution of Meric Indices from Isbister.		
	Left	**Right**
Male	78.8 ±9.4 (n=2)	70.65 ±3.05 (n=2)
Probable male	74.57 ±2.37 (3)	69.73 ±3.71(4)
Probable female	64.05 ±1.20 (2)	-
Female	76.8 ±3.8 (2)	71.1 ±5.59 (3)
All male	76.26 ±6.56 (5)	70.03 ±3.53 (6)
All female	70.43 ±8.02 (4)	71.1 ±5.59 (3)

Different values occur for the sides in males (χ^2=1.907, p=0.04) but not overall females (χ^2=0.130, p=0.90). This may indicate some sexual distinction in activity patterns.

Cnemic index: the relationship between anteroposterior and mediolateral diameters of the tibial diaphysis.

Table 99. Number of Left and Right Femora from Isbister in Different Cnemic Classes.				
	Definition	**Left Side**	**Right side**	**Total**
Hyperplatycnemic	I≤54.9	1	2	3
Platycnemic	55<I<62.9	5	1	7
Mesocnemic	63<I<69.9	3	4	7
Eurycnemic	I≥70	1	1	2
Mean Values		62.01±5.39	62.63±6.77	62.28±5.86

The apparently greater proportion of left-side platycnemia is not statistically significant. Mean values are similar for each side.

Both platymeria and platycnemia are associated with muscle development, especially implicating lower limb flexion. The calculated values suggest strong lower limbs and activity that was likely to be asymmetric for males, implicating the right lower limb in greater use.

Demographic Features at Banks

The minimum number of individuals in this assemblage is indicated by the femora, with nine juvenile right femora and six (possibly seven) adult left femora, for a total of 15. The age ranges suggested by these are consistent with the ages at death from other elements. A single ischium exhibits a developing epiphyseal flake, which supports identification with a juvenile aged in the early teens; two other ischia (probably a pair) are slightly smaller than this, without any sign of epiphyseal development, and probably belong to a slightly younger individual. There are numerous vertebrae that exhibit different degrees of development and many ribs that have varying degrees of epiphyseal development at the heads, expected to occur at 17-25 years (Scheuer and Black 2000). These are consistent with adult longbone ages.

Table 100. Consistency of Age Attribution Across Elements from Banks.

Age attribution of element in years or by age group, one in each unless otherwise noted (e.g. **xA = ** adults; 2-4 = one individual aged 2-4 in that row)

Maxilla		Mandible	Frontal		Humerus		Radius		Ulna		Femur		Tibia		Fibula	
L	R		L	R	L	R	L	R	L	R	L	R	L	R	L	R
				0-0.5								0.5-1				
0.75-1.75	1-1.75	1-2	1-2	1-2		1-2		1.5-2.5		0.75-1.25		1-2	1-2	1-2		
1-2	1-2	1-2	1-2	1-2		1.5-2.5		1.5-2.5		1-2	1.5-2.5	1.5- 2		1.5-2		1.5-2.5
2-4										1.5- 2.5		1.5-2.5		1.5-2.5		
2-4						2-2.5						2-2.5		2-2.5		
2-4	3-5				2.5-3.5			2.5-3.5	2.5-3.5	2.5- 3.5		2.5-3.5		2-3		2-3
					4-5							3.5-4.5	4-5			
7-11		6-11	As maxillae		6-7		7-9					6-8	6-7			6-7
8-13			As maxillae		6-8	6-8	7-9					6-8				6-7
							J	J	2xJ	2xJ	J		3xJ	J		
17-25		17-25														
		17-25														
		17-25														
4xA		3xA			4xA	5xA	3xA	2xA	4xA	3xA	6xA	5xA	2xA	3xA	5xA	4xA
12 individuals		**9**	**4**	**4**	**8**	**9**	**6**	**6**	**7**	**9**	**8**	**14**	**8**	**9**	**5**	**8**

NB. Uncertainty is accounted for by ascribing age using general terms such as ‘adult’ or ‘juvenile’.

The adults, include three young adults (i.e. aged 17-25) and probably at least two mature adults (i.e. aged 35+ from dental attrition). One adult was probably 50+ at death because a nearly complete ossified thyroid cartilage was recovered (Figure 70) and this usually only ossifies to such a degree relatively late in life (Krogman and Íşcan 1986:127-9). It is likely that the most worn teeth in the assemblage came from this individual.

Figure 70.
Ossified thyroid cartilage BSR(118).

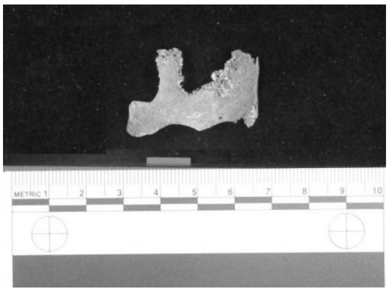


Table 101. Summary of Age Distribution at Banks Tomb.		
Age	**Number of individuals**	**Notes**
0-1 Year	1	
1-2 Years	2	
2-5 Years	4	
Older children (6-12 Years)	2	Longbone development suggests 2 aged 6-9; dental and ischial development suggest 1 each aged 7-11 and 8-13
Young adult (17-25 Years)	3	
Adult (other)	3	At least one old at death
NB. Age groups differ from Isbister due to manner of determinations.		

Like Isbister, there appears to be under-representation of infants but a large number of other juveniles (Table 101 above). This may be misleading because of the limited volume of the tomb deposits excavated.

Sex Distribution at Banks

Sex was only attributed for those adult bones where there was sufficient dimorphism to allow some confidence in the attribution. The numbers of sufficiently well preserved ossa coxae (one each male and female) and long bones were too small to affect the figures suggested by cranial morphology.

Table 102. Adult Sex Distribution at Banks.

Sex	**Crania**	**Femora (L)**	**Femora (R)**
Male	2	1	1
Probable male	2	1	-
Indeterminate	1	1	-
Probable female	-	1	-
Female	1	1	2

Males appear to outnumber females in the adult assemblage (4:2) but this is a small sample, from a limited volume of excavation and may not be representative of the population.

MNI at Banks

The current estimate of MNI from the limited excavation at Banks is 15. This seems certain to rise significantly following further excavation. If the deposition of bone is proportional to area excavated, then total MNI may ultimately rival Isbister and Quanterness.

Table 103. Sex Attribution at Banks from Lower Limb Bone Measurements (Stewart 1979).				
ID	**Element**	**Dimension**	**Measurement**	**Sex Inferred**
BSR(129)	Left femur	Head diameter	43mm	?Female
BSR(129)	Left femur	Neck diameter	31mm	Indeterminate
BSR(138)	Left femur	Head diameter	45mm	Indeterminate
BSR(138)	Left femur	Neck diameter	30mm	Indeterminate
BSR(707)	Left femur	Head diameter	49mm	Male
BSR(707)	Left femur	Neck diameter	34mm	Male
BSR(707)	Left femur	Bicondylar breadth	85mm	Male
BSR(1314)	Right femur	Head diameter	40mm	Female
BSR(1314)	Right femur	Neck diameter	29mm	Female
BSR(1314)	Right femur	Bicondylar breadth	72mm	Female
BSR(1343)	Left femur	Head diameter	40mm	Female
BSR(1343)	Left femur	Neck diameter	28mm	Female
BSR(1361)	Right femur	Head diameter	39mm	Female
BSR(1361)	Right femur	Neck diameter	28mm	Female
BSR(1361)	Right femur	Bicondylar breadth	69mm	Female
BSR(1398)	Left femur	Head diameter	44mm	Indeterminate
BSR(1398)	Left femur	Neck diameter	30mm	Indeterminate
BSR(1627)	Right femur	Head diameter	50mm	Male
BSR(1627)	Right femur	Neck diameter	32mm	Male
The association of femoral neck diameter with head diameter does not permit any additional attributions of sex in these cases.				

There were no significant differences in sex attribution between parts of the same bone, unlike Isbister, which might support an interpretation of separate populations.

Table 104. Sex Attribution at Banks from Upper Limb Bone Measurements (Stewart 1979).				
ID	**Element**	**Dimension**	**Measurement**	**Sex Inferred**
BSR(1047)	Right humerus	Vertical head diameter	46mm	Indeterminate
BSR(1221)	Left humerus	Vertical head diameter	46mm	Indeterminate
BSR(1344)	Right humerus	Vertical head diameter	39mm	Female
BSR(184)	Left humerus	Vertical head diameter	44mm	Indeterminate
BSR(875)	Humerus side uncertain	Vertical head diameter	41mm	Female
BSR(1364)	Right scapula	Glenoid, vertical	35mm	Indeterminate
BSR(1397)	Left scapula	Glenoid, vertical	31mm	Female
BSR(1363}	Left scapula	Glenoid, vertical	40mm	Male
BSR(336)	Right clavicle	Length	136mm	? Female

As at Isbister, a high proportion of Banks bones were indeterminate for sex (Tables 103, 104 above) but the Banks sample is very small.

Banks: Stature and Proportions

Table 105. Stature Estimations for Banks from Single Long Bones.				
Find No.	**Element**	**Dimension**	**Measurement**	**Stature (after Trotter 1970)**
BSR(138)	Left femur	Length	438mm	167.1 ± 3.9cm tall if male (163.6cm Pearson 1899)
BSR(184)	Left humerus	Length	310mm	167.7 ± 4.6cm tall if male (160.4cm Pearson 1899)
BSR(1221)	Left humerus	Length	295mm	163.4 ± 4.6cm tall if male (156.0cm Pearson 1899)
BSR(1362)	Right tibia	Length	338mm	163.7 ± 4cm tall if male (159.0cm Pearson 1899)
BSR(124)	Right tibia	Length	322mm	159.9 ± 4cm tall if male (154.9 ± 3.7 if female) (155.2/150.5 Pearson 1899)
BSR(1344)	Right humerus	Length	282mm	152.7 ± 4cm if female (149.1cm Pearson 1899)
BSR(1319)	Right fibula	Length	314mm	151.6 ± 3.6cm tall if female
BSR(1314)	Right femur	Length	394mm	151.4 ± 3.7cm tall if female (149.5cm Pearson 1899)
BSR(971)	Left radius	Length	201mm	150.2 ± 4.2cm tall if female (148.4cm Pearson 1899)
BSR(1343)	Left femur	Length	380mm	148 ± 3.7cm tall if female (146.8cm Pearson 1899)
BSR(968)	Right fibula	Length	295mm	146 ± 3.6cm tall if female

Stature estimates are consistent with Isbister. The tallest individual adult represented by this small group of bones was probably a male about 167 ± 4 cm (about 5'6 ½") in height; the shortest was probably a female about 146 ± 4 cm tall (about 4'9 ½")). Each estimate has a large associated error so that different estimates are consistent with a single individual but no two elements can be confidently associated. The crude estimates might easily relate to a small number of individuals (indicated by shading in Table 93). The upper and lower limb bones give similar stature estimates. These come from a small number of observations but may imply that upper and lower limbs had lengths that would be considered proportionate today.

Table 106. Osteometric Indices from Banks: Meric Index.

ID	**Element**	**Index**	**Sex**	**Implication**
BSR(115)	Left femur	77.1	Unknown	Platymeric
BSR(138)	Left femur	76.5	Unknown	Platymeric
BSR(887)	Left femur	74.4	Male	Platymeric
BSR(887)	Left femur	71.9	Female	Platymeric
BSR(1343)	Left femur	71.9	Female	Platymeric
BSR(1398)	Left femur	67.6	Unknown	Platymeric
BSR(1314)	Right femur	62.9	Female	Platymeric
BSR(1361)	Right femur	61.3	Female	Platymeric

Table 107. Osteometric Indices from Banks: Cnemic index.

ID	**Element**	**Index**	**Implication**
BSR(124)	Right tibia	67.7	Mesocnemic
BSR(1362)	Right tibia	62.9	Platycnemic

The meric indices (Table 106 above) are greater on the left side than on the right. Although right-side calculations could only be made for two female femora, this may indicate asymmetry.

Marischal Museum Collections

Table 108. Dental Age Attributions for Knowe of Rowiegar (showing numbers of individuals).			
Age from Maxillary Dentition (years)		**Age from Mandibular Dentition**	
Adults	**Juvenile**	**Adult**	**Juvenile**
4 x 17-25 (1F)	1 x >6	5 x 17-25 (1M)	1 x 5-7
4 x 25-35	1 x 6-10	5 x 25-35 (1M)	1 x 5-11 [a]
1 x 35-45	1 x <18		1 x 12-18 [b]
1 x 45+		1 x 35+	
2 x A (1M)		4 x A (2F)	
Un-aged fragments, possibly 2 additional individuals			
[a] Length of one clavicle indicates an individual 7-9 years old; [b] Supported by state of development of one tibia and an os coxae.			

The MNI for Rowiegar is 19, based on the numbers of mandibles and increased because postcranial elements indicate the presence of a juvenile aged 1-2. The numbers and age distribution of crania are consistent and the age distribution of measurable juvenile longbones is also consistent.

Table 109. Sex Attributions from Rowiegar Crania.			
	Frontals	**Occipitals**	**Temporals**
Males	6	1	5
Females	4	3	1
Sex Indeterminate	2		1
Juveniles	3	2	2

Table 110. Postcranial Bones from Knowe of Rowiegar.					
Bone	**Uncertain**	**Adult**		**Juvenile**	
		Left	**Right**	**Left**	**Right**
Atlas	-	6		-	
Axis	-	4		-	
Ribs	-	1 right first rib		1 first rib, 1 other	
Lumbar Vertebrae	-	11		1	
Os Coxae	-	2M, 1?	2M, 1F	(1?)	1
Clavicle	-	5	3	2	-
Scapula	-	1	1	1	-
Humerus	-	6	4	3	
Radius	-	1	1	3	
Ulna	-	4	3	-	
Metacarpals	3	Two third	1 third	-	
Femur	-	3	1	-	1
Patella	3	3	3	-	
Tibia	-	4	5	1	2
Fibula	1	1	2	-	
Calcaneus	-	7	6	1	1
Talus	-	6	8	1	
Pedal Phalanges	-	2 proximal first ray		-	
Other	1 vertebra fragment, 1 loose tooth				

There is a distinct lack of small or fragile elements in these collections, which probably reflects poor collection efficiency and lack of retention. The absence of vertebrae but presence of infant longbones in particular may indicate that taphonomy and excavation rather than a lack of deposition was the cause. This will have affected the reliability of observations, especially skeletal representation, age or sex distribution and prevalence rates of skeletal conditions.

Overall, the collections support observations that: recovery related to size, robusticity and identifiability of bones; males outnumbered females in the tombs; and that infants are underrepresented but children and young adults appear to be overrepresented.

The numbers of individuals, demographic structure and the condition of the remains provide the basis for any further discussion of the significance of skeletal data. The next section describes evidence of palaeopathology, which gives information regarding health status, risks and activities.

3.6 PALAEOPATHOLOGY

Congenital Conditions at Isbister

Numerous 'epigenetic' features have been described for the human skeleton (e.g. Berry and Berry 1967; Finnegan 1978; Turner *et al*. 1991). Their causes are somewhat obscure but most relate to minor variations in anatomical development of genetic or environmental origin (including behaviour patterns).

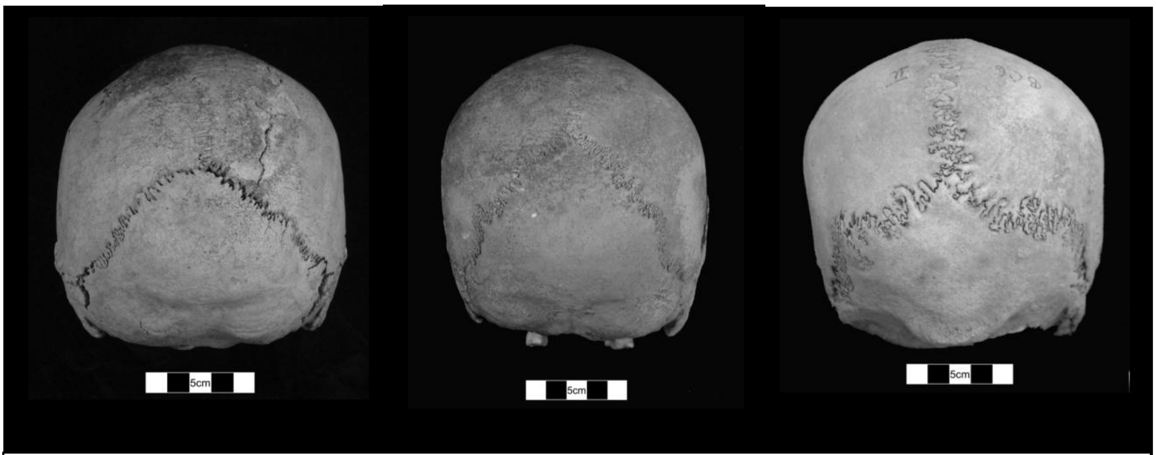


Figure 71. Varying interdigitation and linearity of the lambdoid suture.
Left: IS(1957), centre: IS(1965) (note asymmetry), right: IS(1963) (note nuchal crest).

Though epigenetic features were scored, obliteration, palaeopathology and taphonomy were felt to be possible confounding issues in examining some non-metric variations. For example IS(1767) died in young adulthood but with the sagittal and inferior coronal sutures obliterated; often only parts of a cranium could be identified, sometimes giving a score for one region but not others. No pattern was observed in most variables: supraorbital foramen expression for example: 49:7 (open:foramina) left side and 48:8 on the right; only one individual had foramina bilaterally. Cranial sutures varied widely in form, especially the lambdoid, and wormian bones and ossicles were common but varied greatly in size and location (Figures 71, 72, 73, 74).

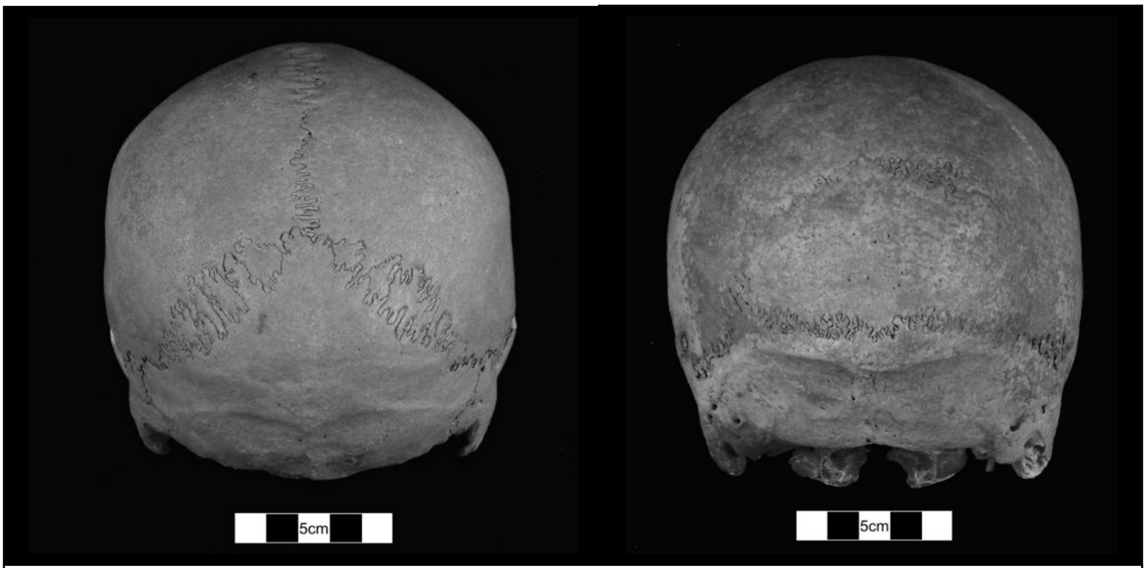


Figure 72. IS(1968) with lambdoid ossicles, IS(4440) with Inca bone.

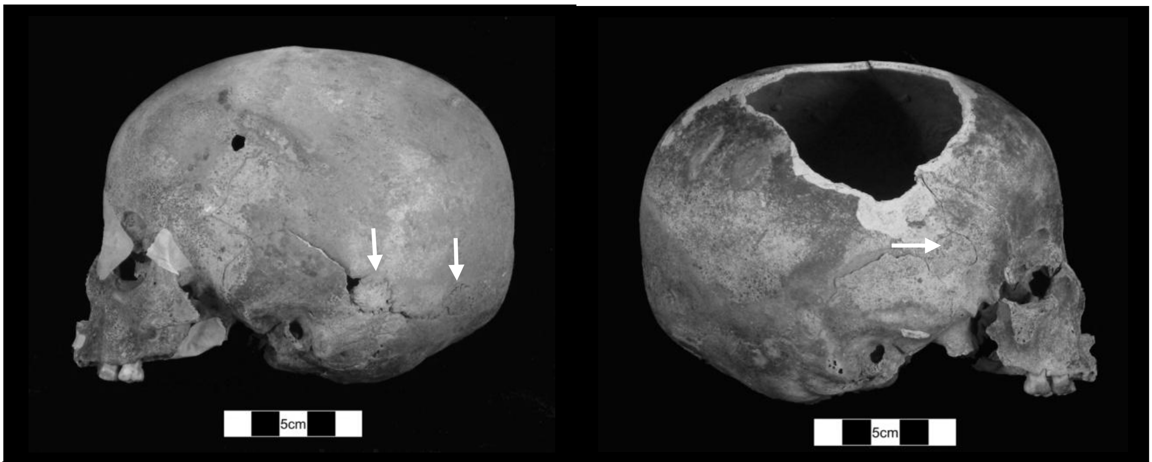


Figure 73. IS(1959): lambdoid, squamosal, asterional and pterional ossicles (arrowed).

Figure 74.

IS(1972): temporal ossicles.

Table 111. Cranial Ossicles Recorded from Isbister, with age and sex attributions.		
Location/suture	**Observed left**	**Observed right**
Lambda	1xC, 1xYA?, 2xAM(Inca bones)	
Lambdoid	2xC, 1YA?,1YAF, 1AM, 1AF	2xC, 1YA?, 1YAF, 1A?, 3M,1F
Asterion	1C, 1YAM, 1F, 1M	
Squamosal	1C, 1F	
Pterion	1F	1C, 1F
Others	Possible left parietal ossicle in adult	
None	3C, 2YA?, 7YAM, possYAF, 1A?, 8AF, 7AM	
Crania were scored for this table only when mostly complete and in adequate condition A=adult; C=child; YA=young adult; F=female; M=male; ?=indeterminate sex		

Wormian bones

These are supernumerary bones that develop in the cranial sutures as a result of minor growth abnormalities and usually have no particular clinical implications. They may be hereditary but can be related to cranial trauma or malformation. Such variation may imply that any genetic or environmental aetiology is not uniformly expressed. In some cases at least, there is evidence of premature craniosynostosis: e.g. IS(1959), aged 5-6 years at death, exhibited partial fusion of the lambdoid suture(Figure 73) and IS(1966) (Figure 76).

Table 112. Age and Sex Relatedness of Supernumerary Cranial Ossicles.					
Group	**All Males**		**All Females**		**Total**
	YA	**A**	**YA**	**A**	
Present	2	4	2	5	14(+4C)
Absent	7	7	?1	8	25(+4C)

Comparing the sexes overall (Table 112), any difference in prevalence is insignificant. One feature that may be significant is the relatively large number of young adult males that did not exhibit ossicles compared with females

(Fisher's exact test, 1-tailed, p=0.069 (χ^2=4.2 but sample size is small)), implying that there may be some sex-related feature associated with likelihood of survival.

Post bregmatic concavity

Post-bregma concavity (or depression) was more certainly identifiable and only one case was recorded of possible confusion with parietal thinning.

Table 113. Expression Scores for Occipital Bossing and Post-bregma Concavity at Isbister.

	Adult Expression					Juveniles	
Score	**1**	**2**	**3**	**4**	**5**	**Y**	**N**
Post-bregma concavity	4	14	8	6	4	6	2
Occipital boss	7	7	6	9	6	4	3

Juveniles were scored Yes/No, ignoring potential problems of change during maturation.

Table 114. Age and Sex Distribution of Post-bregma Concavity.

Age	Post-bregma concavity			No Post-bregma concavity		
	Male	**Female**	**Total**	**Male**	**Female**	**Total**
A	4	4	10	2	4	7
YA	3	0	4	0	1	1
OC			1			5.5
YC			1			0.5

There is a contrast in proportions of males and females in which post-bregma concavity is manifest: males tend to have a post-bregma depression, females tend not to. Fisher's exact test suggests that the distribution of adults vs. young adults is random but probability of the distribution being random for sex is p=0.17 and p=0.07 for adults vs. children (males:females χ^2=2.10, p=0.15; all adults:children χ^2=3.519, p=0.06; adults:young adults: χ^2=0.749, p=0.39 respectively, with 1 degree of freedom but some small samples). The null hypothesis, that the condition is randomly manifested with respect to adult age at death may be accepted but there is a clear distinction between children and adults. This suggests either that it develops with age or that it is related to survival. There is some support for a sex distinction but it is not clear.

Post-bregma concavity (e.g. Figure 75) may be associated with other cranial features such as craniosynostosis, occipital bossing/posterior parietal flattening (Cohen 2000), which exist in the sample.

Figure 75. IS(1954), Exhibiting Post-bregma Concavity. (The lambdoid suture has sprung, exaggerating a posterior flatness.)

Occipital bossing

Occipital bossing (see Figure 76) has been described as rare (0.8% normal births: Hsieh *et al*. 2004). At Isbister, crude prevalence was 46%). The high prevalence may indicate some systematic factor of aetiology in the Neolithic generally: the condition is clearly illustrated in several texts describing Neolithic crania (e.g. Wilson 1851:168-9) and a prevalence of 48% was recorded with breech births in Taiwan (Hsieh *et al*. 2004).

Figure 76. Young adult cranium IS(1966), Exhibiting 'occipital bossing' (bracket), also exhibits asymmetry and Wormian bones, possibly due to premature closure of sagittal and right-side sutures.

Table 115. Age and Sex Distribution of Occipital Bossing at Isbister.						
Age	**Occipital boss**			**No Occipital boss**		
	Male	**Female**	**?sex**	**Male**	**Female**	**?sex**
A	5	2	2	4	4	3
YA	4	0	1	1	2	1
OC			1			3.5
YC			1			0.5
Sum	9	2	5	5	6	8
Total	16			19		

There is a difference in numbers of males and females that exhibit occipital bossing: males tend to, females tend not to (Table 115). Statistical tests are suggestive (Fisher's exact test p=0.09; χ^2=3.143, p=0.08) but do not strongly support rejection of a null hypothesis of random distribution between the sexes in adults. Accepting a sex-related difference, it could be that females with occipital bossing did not survive to adulthood or that they were not so frequently interred in the tomb; or it may be that the condition was linked to behaviour or genetically more prevalent in males. It is possible that individuals with occipital boss tend to be attributed as male and vice versa. The figures suggest that the condition is randomly manifested with respect to age group. This may suggest that the adults of indeterminate sex with occipital boss are more likely to be male but the indeterminate individuals without the condition would be equally likely to be of either sex. It may further be suggested that the excess males (over females) in the tomb tend to be individuals with occipital bosses, which could reflect a particular phase of deposition.

It was found that some crania exhibited unusual profiles, especially asymmetry. This was attributable in many cases to craniosynostosis, where premature fusion of part of a cranial suture led to compensatory contralateral growth. Some crania exhibited dysplasia likely to indicate multiple suture involvement. Ocular dysplasia was potentially inferred by reduced orbit size in two cases. Some asymmetry is normal but the Isbister crania exhibit a greater prevalence than expected (Cohen 2000:113). This was difficult to evaluate because of taphonomic effects, which limited metrical analysis and may have contributed deformation. Table 116 below summarises the subjective evaluations.

Figure 77. Juvenile Cranium IS(1955), Highly dysplastic, with occipital bun, post-bregma depression, protuberant frontals and multiple suture closure. Aged 6-7 years at death.

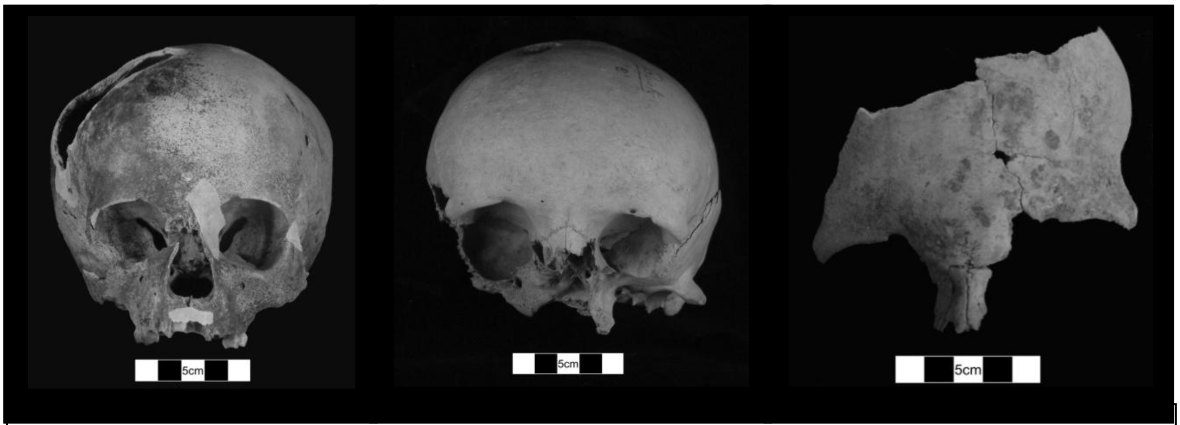


Figure 78. Examples of orbit asymmetry: (L-R) IS(1959), IS(1972), IS(2781).
IS(1972) and IS(2781), at least, may have had unilateral vision impairment.
IS(2781) may have had deformation of the viscerocranium from trauma, the other examples were probably caused by craniosynostosis.

Table 116. Cranial Deformity at Isbister.						
Group	**YA**			**A**		
	M	**F**	**?**	**M**	**F**	**?**
Symmetrical	3	-	1	3	2	2
Slight Asymmetry	-	-	-	2	2	-
Plagiocephaly	-	1	-	1	2	-
Sagittal keeling	-	-	-	3	3	-
Coronal Ridge	3	2	-	7	7	1
Metopic Bulge*	-	-	-	2	2	-

* In two cases, the metopic bulge was thought to verge on mild trigonocephaly.

The presence/absence summary scoring is inevitably subjective but based on Table 13 (p127).

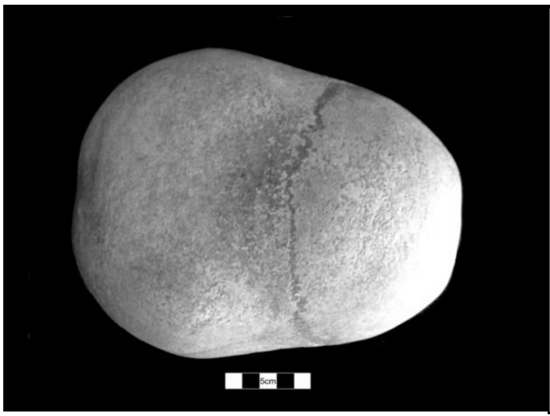


Figure 79. Cranium IS(7352). Fusion of sagittal suture but open coronal suture has resulted in bilateral concavity (cf. Thurnam 1865).

For juveniles, craniosynostosis was considered present when any major suture was partly obliterated. Of the juveniles that could be assessed, 11 were classed as exhibiting craniosynostosis and only one was recorded as probably free of the condition. Three were classed as plagiocephalic and two as borderline trigonocephalic. The frontosphenoid and sphenotemporal sutures were most often implicated: one affected cranium also exhibited metopism. All identified juvenile cases were aged 4-11 years at death (see e.g. Figures 77, 80).

Figure 80. Cranium IS(1956). Asymmetry of orbits and vault (see anterior aspect, right); coronal ridge (white arrow) and post bregma concavity (grey arrow) also present.

Double faceting of the occipital condyles

Occipital condyle double facetting (Figure 81 below) is a minor feature caused by cartilage surviving later in development than normal. Atlanto-occipital double facets (and triple faceting) were reported as having a high prevalence at isbister (Chesterman 1983:100-110) but this was the result of misidentification of normal juvenile crania (e.g. Chesterman 1983:102-3 Ill.34), as is also true of the reported metacarpal/metatarsal epiphyses (Chesterman 1983:114). Such double faceting does occur but the examples were particularly slight and would probably not usually be scored. Only one older individual exhibited a clear condylar groove.

Figure 81. Double facets of the occipital condyles. Adult male cranium IS(1768).

A more unusual feature of the occipital condyles in one individual (IS(4440)) was marked angularity dividing each condyle into anterior and posterior facets at about 60° to each other (Figure 44, p188 above). This has an appearance similar to ungulate crania and has previously been described as ‘double faceting' (Chesterman 1983:Ill.49) although it is a clearly distinct condition. This condyle form may have inhibited cranial mobility but did not apparently result in osteoarthritis. A lesser expression is visible in three other individuals, in one case unilaterally (on the right side only). This condition is most likely to have been a developmental abnormality. No atlas was identified that would match these occipital condyles.

Dental Abnormalities

Observation of dental abnormalities of maxillae and mandibles was severely inhibited by pathological and taphonomic factors. Mechanical damage, mineral occlusion, alveolar resorption, antemortem tooth loss, postmortem losses and inappropriate gluing were all significant. Prevalences were difficult to assess and numbers of observations considered reliable varied between conditions.

The cusp patterns of molars included + and Y forms with 4 and 5 cusps, often all in one individual. Shovelling was recorded in a single loose incisor and the Carabelli trait was recorded on several loose molars.

Table 117. Distribution of Mandibular Molar Cusp Patterns at Isbister.
(Number of teeth where cusp pattern observable.)

Tooth \ cusp pattern	**+4**	**+5**	**Y4**	**Y5**
M1	1	5	7	18
M2	16	9	5	2
M3	9	5	0	5

One second mandibular molar had a +6 pattern and one third molar had a Y6 pattern.

There was a tendency for mandibular first molars to have a Y cusp pattern but for second molars to have a + pattern (χ^2=22.585, p<0.001) and for the first molars to have five cusps but the second to have four (χ^2=10.05, p=0.001). There was no apparent difference between sides. This distribution may be considered typical for humans (Hillson 1996:96).

Adult Mandibles

A single right lateral incisor (from 46 sockets) and one left (from 50) exhibited rotation ('winging'). Four right (from 46) and three left (from 45) canines exhibited rotation, another leaned lingually. Two right (from 45) and three left (from 44) second premolars exhibited rotation; another left was displaced medially. The second and third molars of one individual leaned lingually. Two right (from 37) and two left third (from 41) molars were congenitally absent; Two of each were impacted and two (left only) were rotated.

Maxillae

Pseudoanodontia in IS(2694) affected the left lateral incisor/canine and the right canine, first premolar and first molar; this was associated with retained deciduous teeth. The same condition may be exhibited in mandible IS(6699) left canine. Impaction was also noted (associated with a retained deciduous tooth) in a right second premolar, one left and one right canine .

IS(7234) (Figure 82 below) exhibited dysplasia at the premaxillary suture, which resulted in a diastema at the premolar position. There are two conditions that are most likely to have brought this about. Firstly, cleft lip, which is a congenital condition in which development of the maxilla and premaxilla does not occur normally: it is strongly associated with cleft palate, harelip and altered cranial morphologies (Scott and Symons 1977:59). In this case, the expression is likely to have been very minor. The most likely alternative is Streeter's fetal dysplasia, a failure of normal arterial development within a small anatomical area, so that lack of blood supply consequently hinders bone growth (part of a family of dysplasias with a combined prevalence today estimated at between 1/1200 pregnancies and 1/15000 live births (see Cohen 2000:112-8)). The condition will have affected the individual's facial appearance, giving a sunken appearance to the left cheek and probably also affected chewing habits by preventing efficient mastication on the affected side until the existing molars had erupted and come into occlusion. IS(7232) exhibits a diastema at this point, which could belong to the same individual, suggesting a bilateral condition.

Figure 82.
IS(7234), two views showing developmental defect at premaxillary suture.

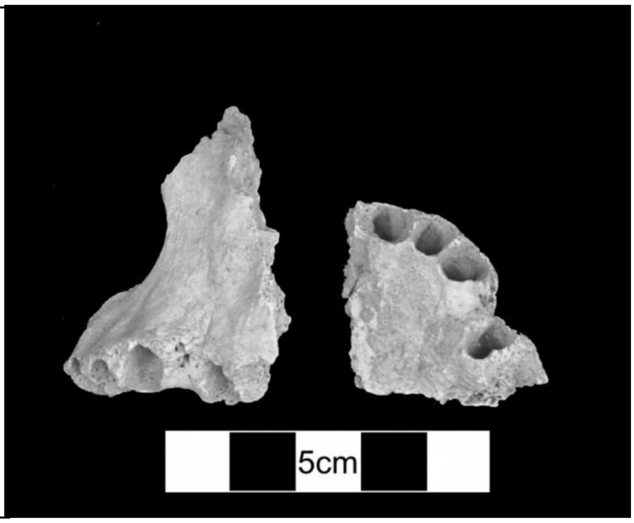
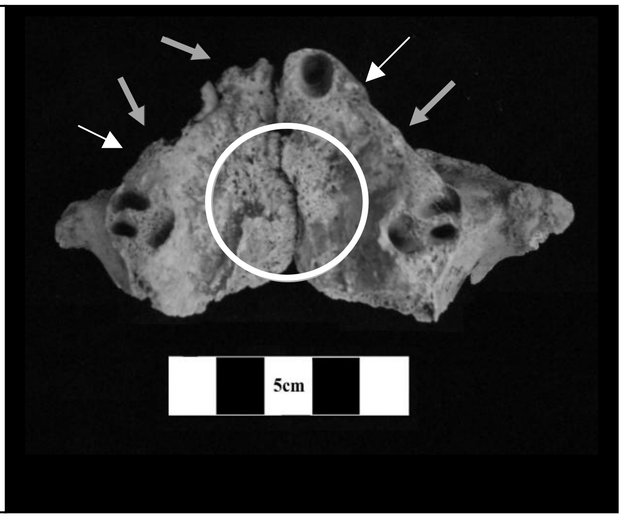


Figure 83. Maxilla IS(2694): ante-mortem tooth loss (grey arrows), pseudo-anodontia (white arrows), dysplasia, alveolar resorption and palatal pitting (circle) (see Knowe of Yarso 5, Figure 91 below).



Rotation was recorded in two left second premolars and one right first premolar.

Congenital absence was observed of three left and two right third molars but two left and two right third molars were impacted; one left third and one right second molar leaned medially.

Table 118. Impaction of Adult Teeth at Isbister.							
Arcade	**Tooth**	**3**	**4**	**5**	**6**	**7**	**8**
Maxilla	Left	1/43	0/39	0/39	0/41	0/23	2/19
	Right	2/43	1/41	1/40	0/38	0/23	2/16
Mandible	Left	1/48	0/43	0/44	0/43	1/42	2/37
	Right	0/46	0/46	0/45	0/39	1/40	2/41

Table 119. Dental Aplasia at Isbister.							
Arcade	**Tooth**	**3**	**4**	**5**	**6**	**7**	**8**
Maxilla	Left	0/48	0/50	0/46	0/41	0/23	3/19
	Right	0/49	0/49	0/49	0/38	0/23	2/16
Mandible	Left	0/55	0/50	0/51	0/53	0/52	2/47
	Right	0/50	0/51	0/51	0/50	0/51	2/51

Table 120. Overeruption of Adult Teeth at Isbister.							
Arcade	**Tooth**	**3**	**4**	**5**	**6**	**7**	**8**
Maxilla	Left	0/11	1/9	0/15	1/41	0/23	0/19*
	Right	0/11	1/7	1/12	0/38	0/23*	0/16*
Mandible	Left	0/5	0/8	0/8	1/34*	1/26	0/22*
	Right	0/4	0/9	0/8	0/35*	0/26	2/19*
* Calculus on occlusal surface – as with overeruption, suggests absence of opposing tooth.							

Table 121. Carabelli Trait in Adult Teeth at Isbister.				
Arcade	**Tooth**	**6**	**7**	**8**
Maxilla	Left	4/41	0/23	0/19
	Right	2/38	0/23	0/16
Mandible	Left	0/34	0/26	1/22
	Right	0/35	0/26	0/19

Table 122. Buccal Pit in Adult Teeth at Isbister.				
Arcade	**Tooth**	**6**	**7**	**8**
Maxilla	Left	0/41	0/23	0/19
	Right	1/38	0/23	0/16
Mandible	Left	3/34	2/26	1/22
	Right	4/35	1/26	3/19

Spina Bifida Occulta

Few sacra from Isbister exhibited abnormalities but few were capable of being examined. Two sacra exhibited spina bifida occulta - a failure of the sacrum arch to fully form and fuse (Figure 84), which is usually of no clinical significance. Chesterman recorded cases of sacralisation of a lumbar vertebra and a supernumerary sacral vertebra (Chesterman 1983:Ill.41) but those bones were not identified in this study.

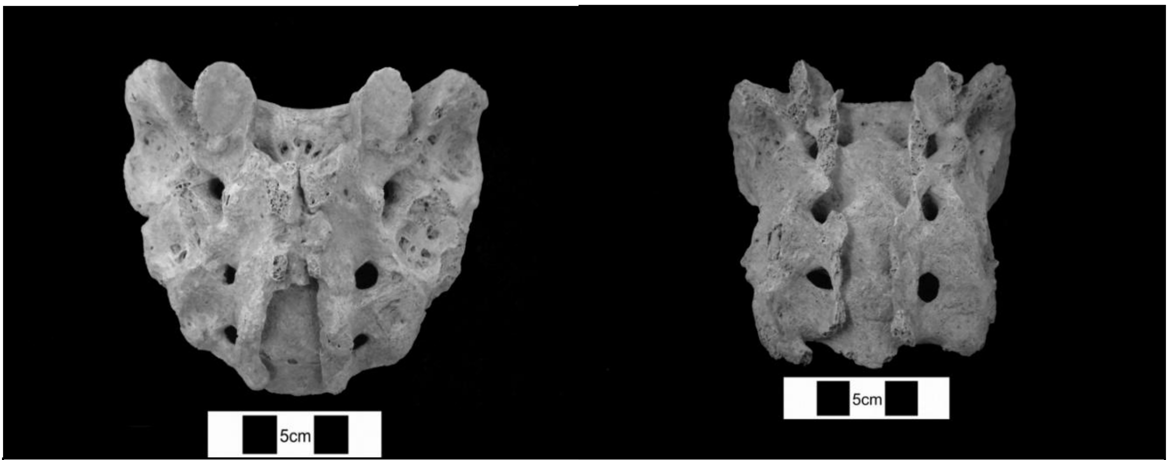


Figure 84. Expressions of spina bifida occulta at Isbister.
IS(5738) (left) and IS(6118) (right).

Coxa Vara

Four femora from Isbister, two each left and right (a minimum of two but possibly three or four individuals), exhibited coxa vara (Figure 85).

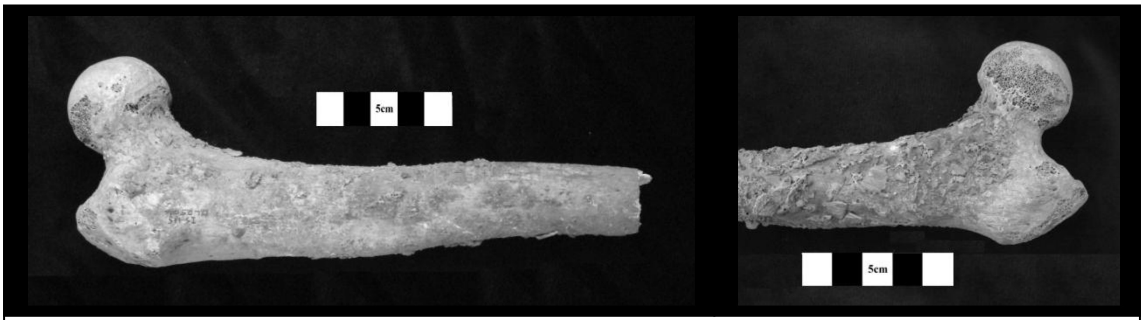
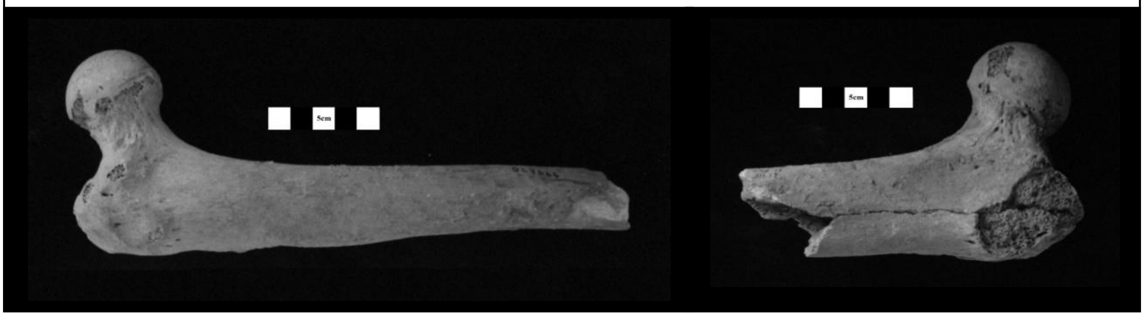


Figure 85. Cases of coxa vara from Isbister.



Coxa vara is an abnormally acute angle between the femoral neck and shaft, which creates a mechanical disadvantage to the muscles used in ambulation, resulting in a clearly abnormal gait. If congenital, then it is caused by bone-softening conditions such as rickets (Adams 1961:338; Resnick and Niwayama 1988:3581). The condition also appears in an illustration of a femur from Bronze Age Scotland, though without apparently being recognised (Bruce 1986:22, Ill.17).

No cases of Allen's fossa were recorded: similar features were either juvenile or attributed to pathological lesions. Other traits will be discussed under MSM.

Congenital Conditions at Banks

Figure 86. Sphenoid BSR(303), showing hypoplastic pterygoid process.

Dysplasia of the pterygoid process in BSR(303) (left of bone in Figure 86) will have had consequences for jaw use (including eating and speaking) since this process anchors the muscles that help to move and control the mandible. This appears to be a congenital condition and the bone surfaces are normal. Such conditions may be genetic in origin and can be part of a craniofacial dysostosis syndrome such as Crouzon or Treacher Collins (Gorlin *et al*. 1990:524ff, 649ff).

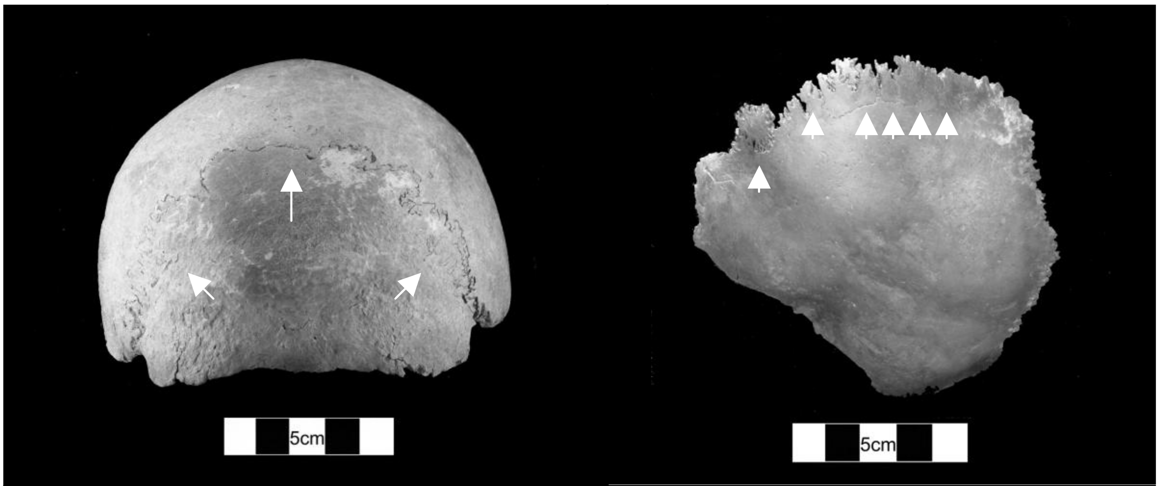


Figure 87. Lambdoid ossicles at Banks.
Left: BSR(137) posterior aspect showing ossicles almost totally obliterated;
Right: BSR(1391) posterior aspect with clear ossicles.

Two crania from Banks exhibit Wormian bones in the lambdoid suture (Figure 87): in each case the ossicles are small and were fusing with the adjoining bones. There is no evidence of malformation, although BSR(137) appears to have an occipital ‘bun’.

There are three examples of ‘winging’ (slight rotation) of anterior teeth in mandibles from Banks: BSR(1359), BSR(1376) and BSR(1378). This last is a juvenile aged 5-11 years at death and it is possible that the condition would have resolved spontaneously had the individual survived.

There is a single instance of a double facetted superior articular surface on an atlas. It is not necessarily rare and was also noted at Isbister.

There is a single example of an Allen fossa, on adult femur BSR(138) (Figure 88a). Allen’s fossa is a perforated area inferiorly on the femoral neck due to retention of a juvenile blood supply. This has no clinical significance.

Figure 88a. BSR(138), exhibiting Allen’s fossa. (Note platymeria and surface concretion.)

Figure 88b. Tibia BSR(121).

Adult left tibia BSR(121) (Figure 88b) has a smooth hemispherical depression in the cancellous tissue that may reflect a space occupying lesion. This could possibly be from a neoplastic growth, residual cartilage or an infection focus. It has provoked no apparent bone reaction and may have been clinically insignificant.

Congenital Conditions at Knowe of Rowiegar

Figure 89. Fused first and second lumbar vertebrae ABDUA90034.

Figure 90. Bifid First Rib ABDUA90039.

It is not impossible that the two bones above (Figures 89, 90) came from the same individual and could represent a developmental abnormality (see Barnes1994:63ff). It is alternatively possible that ABDUA90034 is an example of ankylosing spondylitis (Schmorl and Junghanns 1971:398ff; Ortner 2003:571ff)). Bone development across the vertebrae is apparently symmetrical, with 'squaring,' but contrarily there is no evidence of ossification beyond the L1-L2 body joint and only minor apophyseal pitting. The fusion of the vertebrae is therefore not diagnostic, which may be significant for understanding the antiquity of ankylosing spondylitis (cf. Rogers *et al*. 1985). A similar example was identified at Burn Ground (Smith 2005:155).

Figure 91. ABDUA17588:
fully formed mesial premolars unerupted, despite occlusal second molars.

Mandible ABDUA17588 (Figure 91) has features reminiscent of maxillary abnormalities recorded at Isbister and Yarso in the failure of tooth eruption (Figure 82, Table 119 above; Figure 92 below), which may indicate a common aetiology.

<u>Congenital Conditions at Knowes of Lairo and Yarso</u>

The single surviving Lairo cranium exhibits metopism and its right lateral incisor is hypoplastic (peg-tooth); there is bilateral pitting of the greater wing of sphenoid.

Yarso 5, an adult male cranium (Figure 92), is highly dysplastic with plagiocephaly, bathocrany and pseudo-anodontia (affecting the right canine, both right premolars and both third molars) but with congenital absence of both lateral incisors and crowding of the left canine and premolars (Low 1935:347ff).

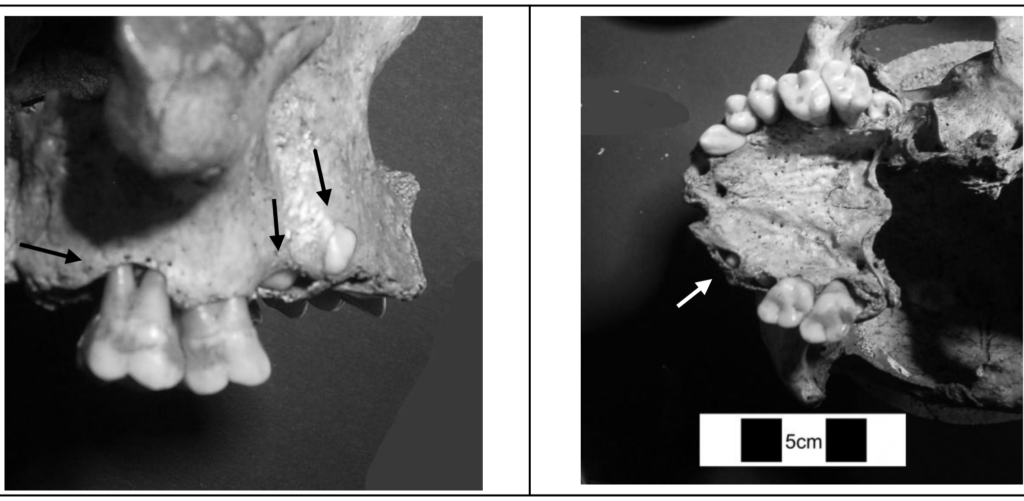


Figure 92. Maxillary arcade from dysplastic cranium Knowe of Yarso 5, exhibiting a pinched appearance anteriorly, pseudoanodontia, tooth crowding, ante mortem tooth loss and periodontal disease. (compare with IS(2694) in Figure 81 above).

Summary of Congenital Conditions

Whilst many skeletal abnormalities have little clinical significance, these assemblages have produced several individuals who are likely to have been of unusual appearance and / or disabled. Coxa vara (p258 above) and various forms of cranial dysplasia are likely to have caused ambulatory difficulties, partial blindness, neurological problems (from intracranial pressure) and possible oral problems (some even affecting speech or mastication - see also pp390ff for other conditions with similar effects). Premature craniosynostosis and related features in particular have been reported from Neolithic tombs throughout Britain (pp10-18 above; Inkster 1963; Roberts and Cox 2003:62-63), as have sacralisation of lumbar vertebrae (see p257 and p296) and a case of clubfoot (Roberts and Cox 2003:63-64), which may support some common factor(s) affecting the individuals represented in the tomb assemblages.

Activity Related Conditions (MSM) and Degenerative Joint Disease (DJD)

Isbister

Osteoarthritis, defined here as cases presenting multiple porotic and remodelling symptoms or eburnation or both (following Rogers *et al*. 1987:185), is widespread in the Isbister assemblage. OA may relate to behavioural patterns but aetiology may include heredity, infection and dietary factors (e.g. Klippel and Dieppe 1998:section 8). (Figures for OA are included in the sums presented here for DJD.)

Degenerative conditions of the TMJ were exhibited both on mandibular condyles and in the mandibular fossae of crania (Figure 93). There was a spectrum of manifestation that included pitting of the bone surface, new bone deposition and eburnation; in some cases, the joint was severely remodelled. The mandibular fossae tend to have remodelled articular eminences suggestive of anterior pressure, which may have reduced joint stability.

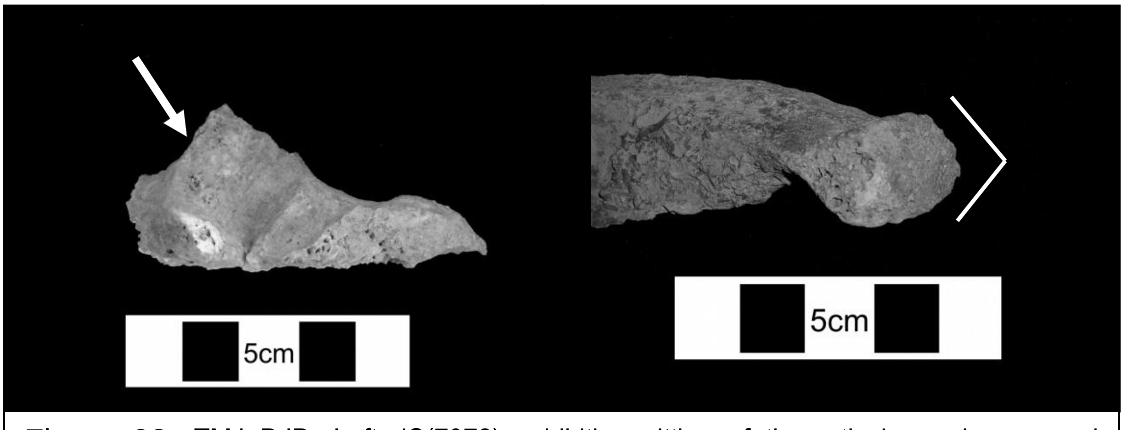


Figure 93. TMJ DJD. Left: IS(7072) exhibiting pitting of the articular eminence and expansion of the mandibular fossa. Right: a dysplastic mandibular condyle from NMS Isbister collection with marked anteroposterior angularity.

In the mandibles, expression of DJD was generally limited to pitting of the articular surface. There were two mandibles in which the (sole surviving) condyle was flattened but angled into distinct medial and lateral facets (Figure 94). There were three cases where the attachment site for *m. pterygoideus lateralis* is marked by a porotic pit, which may reflect a traumatic aetiology or secondary effects from strenuous activity (Figure 95).

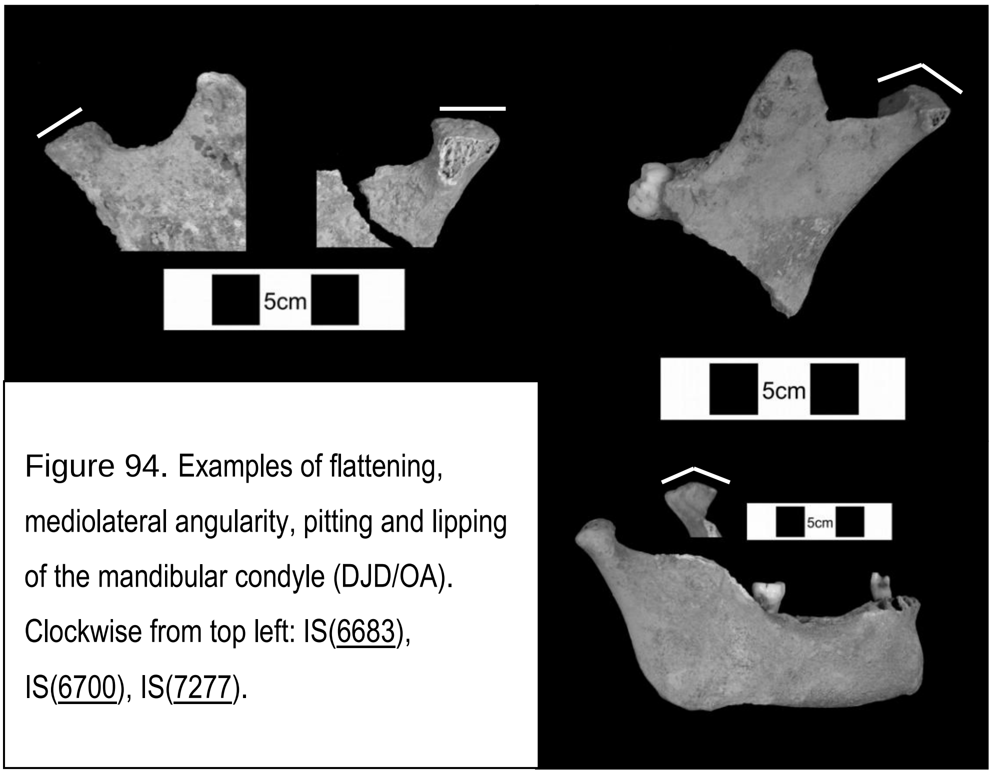


Figure 94. Examples of flattening, mediolateral angularity, pitting and lipping of the mandibular condyle (DJD/OA). Clockwise from top left: IS(6683), IS(6700), IS(7277).

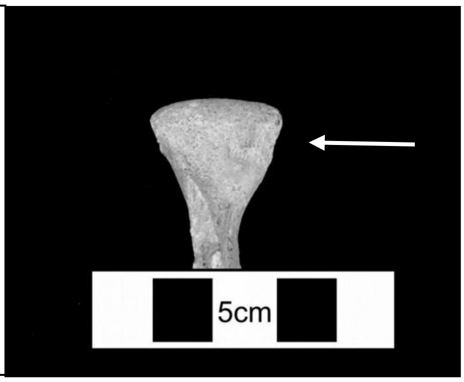


Figure 95. Example of marked pterygoid fovea, for *M. pterygoideus lateralis.* IS(7235).

Form of the mandibular angle was used as an indicator of sex but is essentially related to robusticity of *Mm. masseter* and *pterygoideus medialis*. Three individuals exhibited marked medial flexion (at least one bilaterally), 15 lateral flaring and 9 no flexion; 16 individuals exhibited lateral robusicity (1 unilateral on right), 14 medially and 11 displayed none.

Table 123. DJD of the Temporomandibular Joint at Isbister: Age and Sex Distribution.					
	Cranium			**Mandible**	
	Left	**Right**	**Individuals**	**Left**	**Right**
Male	11/17	13/20	13/25	3/15	3/14
Female	7/15	7/15	8/15	1/5	1/3
?sex	4/5	3/4	4/6	2/5	3/7*
Juvenile	2/9	1/8	2/9	0/14	0/14
Total	24/46	24/47	27/55	6/39	6/37

Table 124. Severity of Cranial DJD at Isbister. Numbers of Cases Observed.			
Condition	**Slight**	**Moderate**	**Severe**
DJD at TMJ (maxillary)	9	4	1
DJD at occipital condyles	5	3	1
NB. Presence was easier to attribute than severity, hence the differences from Table 110 above.			

Table 125. Definitions of DJD Severity Levels.			
Condition	**Slight**	**Moderate**	**Severe**
DJD	Slight lipping and/or porosity over part of the articular surface	Moderate lipping and porosity, new bone formation or slight eburnation	Extensive eburnation or new bone formation with porosity and lipping

DJD of the temporomandibular joint was the major skeletal expression of softening hides among the Sadlermiut Inuit (Merbs 1983:154, 156). Heavy dental attrition from non-masticatory tooth use appears rare in Neolithic Orcadians but trauma could provide a plausible alternative aetiology.

Evidence of TMJ DJD in Isbister (Tables 123, 126) included two individuals aged about 10 years at death. Severity was minor (unsurprisingly for a degenerative condition in juveniles) but this suggests that juveniles suffered significant causative factors, such as stressing activity. The slightly greater prevalence in adult males over females could support interpretations of sex-related activities or selectivity in trauma.

Table 126. Age and Sex Distribution of TMJ DJD at Isbister.

Age	**TMJ disorder**			**No TMJ disorder**		
	Male	**Female**	**?**	**Male**	**Female**	**?**
A	10	8	3	3	3	2
YA	3	-	1	3	3	-
OC			1			4
YC			-			3
I			-			-

TMJ disorder was tested for relatedness to sex and age: for sex, p_{random}=0.263 but for age groups, p_{random}=0.01. There is no clear contrast in numbers of males and females in which the condition is manifest but it appears with age. This is to be expected because DJD is a degenerative condition linked to age. It was however unexpected that there should be any juveniles at all displaying the condition (occipital condyle DJD was also observed in juveniles, see below).

Table 127. Mode and Range for Adult Maxillary Molar Attrition (Scores after Smith 1984).

	C	P1	P2	M1	M2	M3
Right	0-**5**-6 (n=11)	3-**5.5**-8 (7)	2-**2.5**-8 (10)	1-**3**-7 (37)	**2**-7 (23)	0-**2**-5 (13)
Left	2-**3**-6 (9)	**2**-8 (9)	**2**-6 (15)	0-**2**-7 (23)	**2**-7 (21)	0-**2**-5 (12)
Males	2-**3.5**-6 (7)	2-**2.5**-6 (8)	**2**-6 (8)	2-**3**-7 (31)	**2**-7 (23)	0-**2**-5 (18)
Females	5 (1)	5 (2)	**2**-5 (6)	2-**3**-6 (12)	**2**-5 (7)	1-**1.5**-2 (4)

NB. Numbers of anterior teeth and of female teeth are particularly low. See appendix for detailed records.

There are few clear indications of non-masticatory activity in the dentition but this may be due to tooth loss. There is a hint of excessive wear at the right canines/first premolars. Dental attrition was rarely severe in the Neolithic Orcadians (Table 127 above), although the scores may be skewed by losses of opposing teeth and compensatory overuse elsewhere in the arcade. Few teeth exhibit signs of notching or grooving but a group of three loose maxillary incisors exhibit labial striations supero-inferiorly (Figure 96). Two loose maxillary incisors exhibit labial notches to the centre of the occlusal edge (Figure 97).

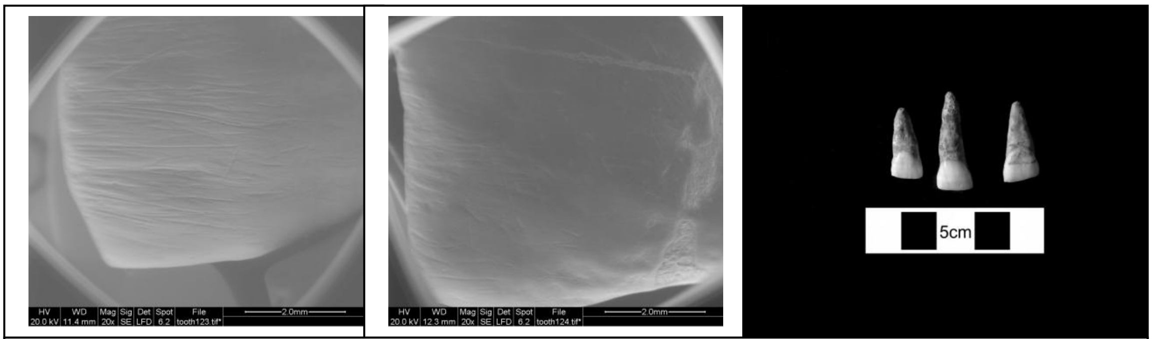


Figure 96. Labial striations in a group of incisors from Isbister, consistent with a single individual.

Figure 97. Two maxillary incisors exhibiting labial notches on the occlusal edge.

Incisal notches may relate to holding or cutting some item oriented into the mouth but labial grooves seem more likely to have resulted from abrasive material being drawn over the surface. Cases of notching to the posterior dentition may best be interpreted as incidental results of masticatory activity.

There is clear indication of non-masticatory activity, in one juvenile (aged 5-9 years at death) mandible. This exhibits circular holes in the mesial surfaces of both deciduous second molars, that on the right penetrating the enamel (Figure 98). This was distinguished from interproximal caries through lack of cavitation, by occurring superiorly to the first deciduous molar on both sides and from implication of the occlusal surfaces of the first deciduous molars, especially distally on the right. It seems that some hard object has bored into the teeth bilaterally. The left second deciduous molar has a small buccal chip occlusally.

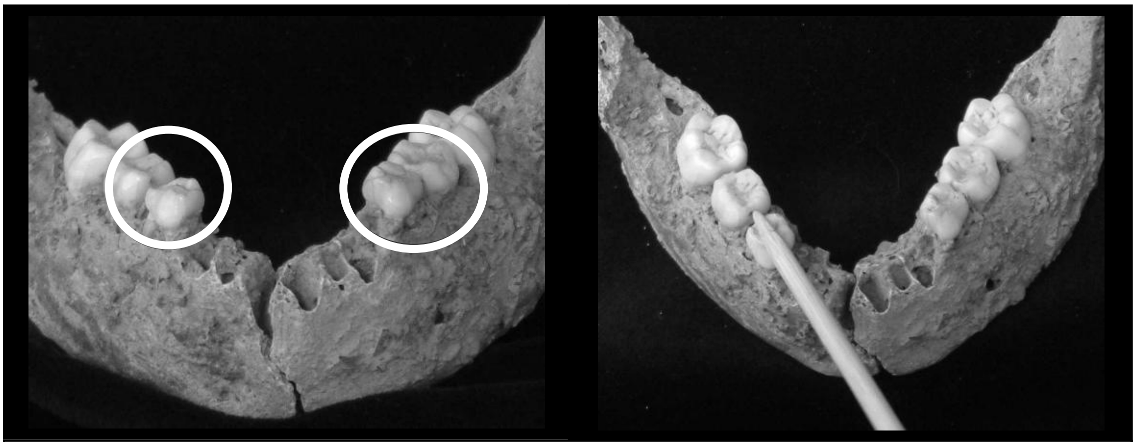


Figure 98. Artificial molar damage in juvenile mandible IS(7168).

A small number of adult molars exhibited mesiodistally concave attritional patterns (e.g. Figure 99) that may reflect similar activities but failure to identify matching jaws prevented proper occlusal study.

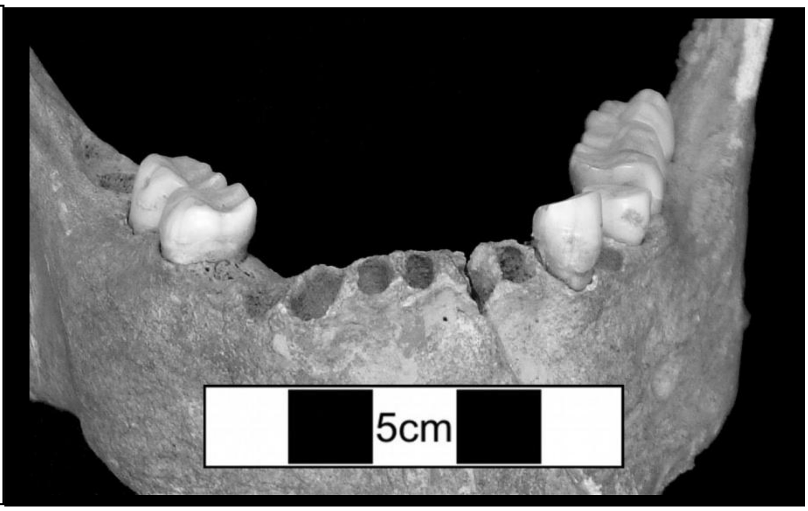


Figure 99. Mandible IS(8767), exhibiting concave wear pattern to the first molars; note also the flattening of the left second premolar.

Robusticity of the muscle attachment sites of the inferior occipital squama, temporal line and inferior aspect of the malar were all recorded, occasionally with exostoses. Males would be expected to exhibit greater robusticity but the proportion with robustness associated with attachment areas for the masticatory muscles is of the same order in both sexes. This may imply activities involving strong jaw use were undertaken equally.

Table 128. Numbers of Individuals from Isbister with Markedly Robust Occipitals.

Group	**M**	**?M**	**?**	**?F**	**F**	**Total**
A	3/6	1/3	0/1	2/5	0/5	6/20
YA	5/7	0/0	1/2	1/4	0/0	7/13
Total	8/13	1/3	1/3	3/9	0/5	13/33
	9/16			3/14		

Table 129. Numbers of Individuals from Isbister with Markedly Robust Temporal Lines.

Group	**M**	**?M**	**?**	**?F**	**F**	**Total**
A	3/8	0/2	0/1	2/4	2/6	7/21
YA	4/8	0/1	1/2	1/5	0/1	6/17
Total	7/16	0/3	1/3	3/9	2/7	13/38
	7/19			5/16		

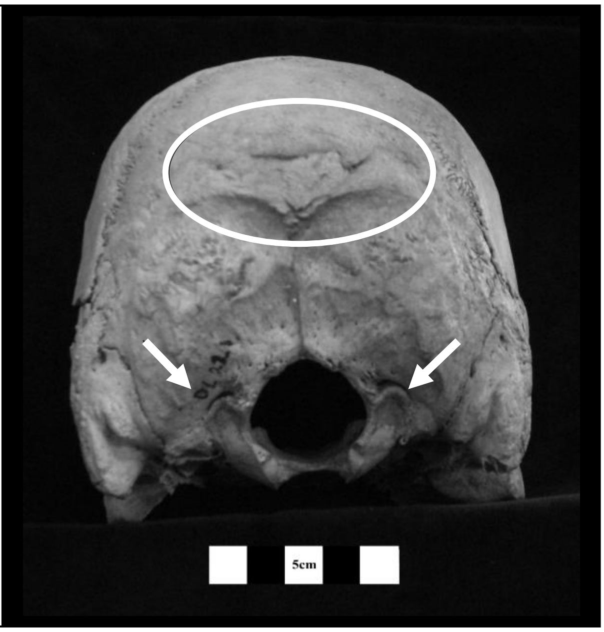
Table 130. Numbers of Individuals from Isbister with Markedly Robust Inferior Malars.

Group	**M**	**?M**	**?**	**?F**	**F**	**Total**
A	1/7	1/2	0/1	2/4	1/4	5/18
YA	4/9	1/1	0/2	2/3	0/1	7/16
Total	5/16	2/3	0/3	4/7	1/5	12/34
	7/19			5/12		

Nuchal Crest Robusticity and Posterior Expansion of Occipital Condyles.

Robusticity of the nuchal crest is commonly used as a sex marker but is essentially related to muscularity of the posterior neck muscles. In several cases from Isbister, expression is marked but appears to be associated with pitting superiorly and with platy exostoses (e.g. Figure 100). This suggests inflammation and possibly trauma that might imply heavy work or weak tendinous tissue. It would be expected to exhibit a relationship to robustness of the mastoid process since *M. mastoideus* would act as an antagonist.

Figure 100. Strongly developed nuchal crest and other robusticity, accompanied by new bone plaques (ellipse). Here associated with posterior expansion of occipital condyles (arrows).



Posterior expansion of the occipital condyles likely to result from hyperextension of the atlanto-occipital joint was also exhibited (Table 131, Figures 100, 101). This was accompanied by lipping and sometimes lateral pitting, which may indicate a degenerative element in those cases. In several instances, expansion had occluded the condylar canal (patency of which is often scored as a non-metric trait) and appears to have resulted in accommodatory enlargement of other foramina. This condition was observed in adults of both sexes and in juveniles as young as 6-8 years old.

Table 131. Prevalences of Pathological Occipital Condyle Conditions at Isbister.						
	Posterior Expansion and Lipping				**Lateral pitting or woven bone**	
	Prevalence		**Severe:mild**	**Severe:mild**		
	Left	**Right**	**Left**	**Right**	**Left**	**Right**
Male	12/14*	11/14	2:1	4:1	2/13	2/12
Female	9/12	10/13	3:1	3:1	5/11	5/12
Uncertain	1/1	2/2	0	0:1	1/1	1/1
Juvenile	4/7	3/6	3:0	2:0	2/7	2/6
Total	26/34	26/35	8:2	9:3	10/32	10/31

* There was one instance of osteochondritis dissecans on an occipital condyle.

Posterior expansion was classified as mild where remodelling was apparent but did not affect surface area; severe where the condylar canal was occluded and moderate in other cases.

There is no obvious evidence for any relationship with sex or of sidedness but condylar expansion is more prevalent in adults than juveniles.

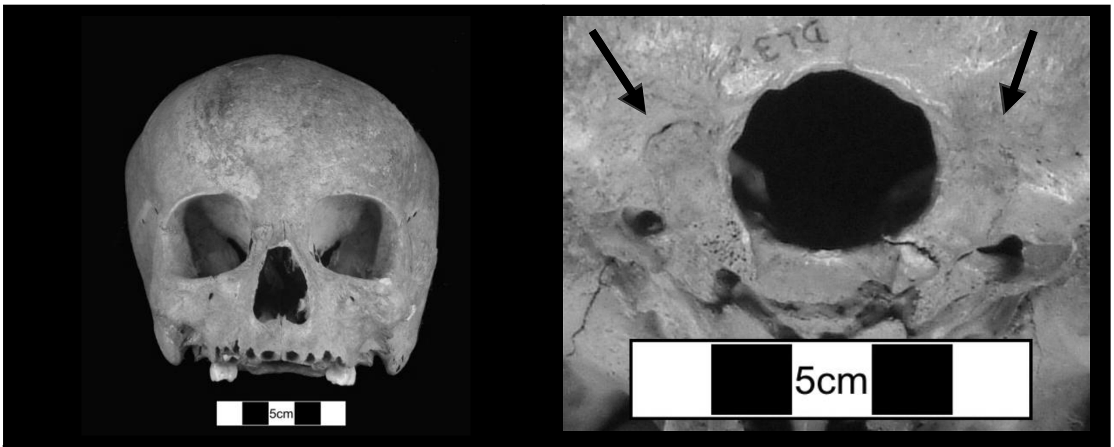


Figure 101. IS(1967), inferior aspect exhibiting complete occlusion of condylar canals; the right cranial foramina (notably the jugular foramen) are significantly larger than the left. This individual died aged 8-12 years and exhibited fusion of coronal, sagittal and the left fronto-sphenoid sutures as well as periodontal disease and cribra orbitalia.

This may indicate that strenuous cranium-related activities were pursued from a very early age and the observed DJD from the occipital condyles might support this. Occipital condyle DJD is more common than its absence (Table132 below).

Table 132. Age and Sex Variation in Occipital Condyle DJD at Isbister.						
Age	**Occipital Condyle DJD**			**No Occipital Condyle DJD**		
	Male	**Female**	**?**	**Male**	**Female**	**?**
A	7	7	3	1	1	
YA	4	2	1	2	2	
OC			4			1
YC						1
I						

There is no clear contrast in numbers of males and females in which the condition is manifest: both sexes may equally have occipital condyle DJD. The age group distribution is also likely to be random but includes juveniles.

One example was recorded of a deep pit in the basilar occipital (Figure 102). It is likely to have been a congenital defect, although basioccipital clefts are rare (Barnes 1994:84). This case is probably related to the pharyngeal raphe and may indicate some abnormality of speech or swallowing.

Figure 102. Occipital IS(7228), showing deep pit (circled); note also the sharp angular curves of the condyles (arrows).

Postcranial Features

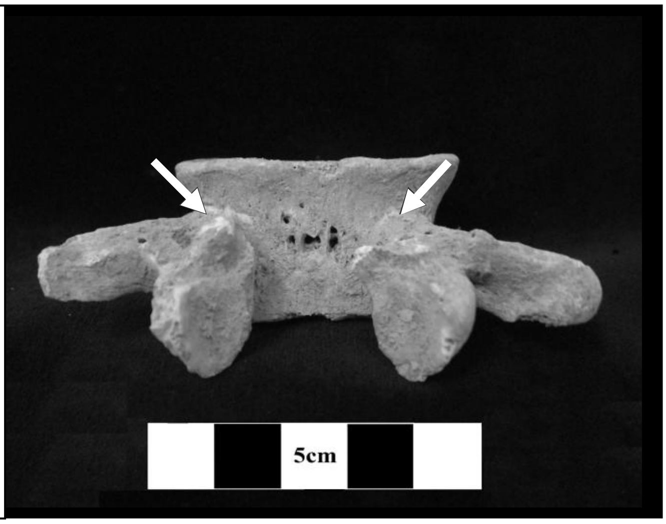


Figure 103.
Spondylolysis. Lower lumbar vertebra, IS(5735), posterior aspect.

There is a single case of spondylolysis (IS(5735)). This suggests an individual having undergone flexion with force early in life and is reported to have a prevalence between 3% and 10% in modern adults (Mann and Hunt 2005:90-4).

IS(7051) is a complete first thoracic vertebra exhibiting 'clay shovellers' fracture' (Figure 104). The tip of the neural spine flares bilaterally and is pitted and rough, indicating pseudarthrosis associated with avulsion of the tip. The articular facets display eburnation, pitting and marginal lipping. The inferior surface of the neural spine has undulating ridges of new bone laterally on both sides. These features are consistent with strenuous activity.

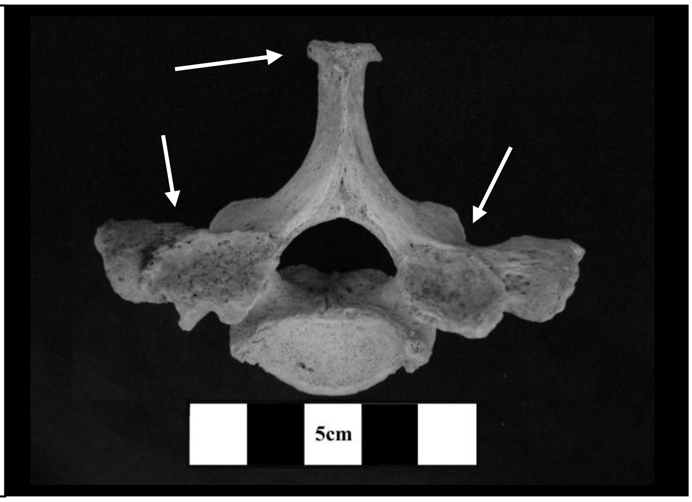
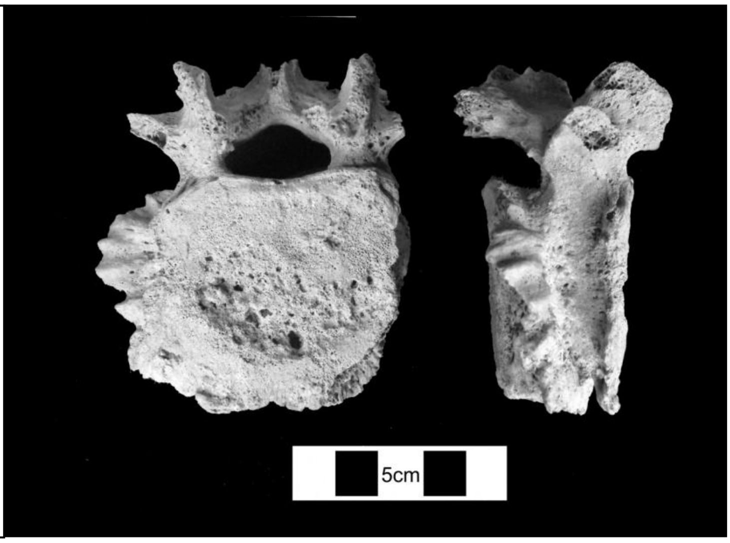


Figure 104. Clay shoveller's fracture. IS(7051), superior aspect. Note also the lipping and pitting of the apophyseal surfaces.

Other than these special cases, DJD was noted throughout the spine (i.e. on articular facets of all types). Schmorl's nodes osteophytosis, articular pitting, lipping and eburnation were all recorded. The recovery of thoracic and abdominal elements was very poor and fragmentation high, so that no estimates of prevalence distribution through the spine were considered practical.

Figure 105.
Lumbar vertebra exhibiting florid osteophytosis.



IS(<u>6138</u>) (Figure 106) is a manubrium displaying considerable rugosity for muscle attachments. The clavicular notches are almost coaligned on the superior margin, the jugular notch almost lost to occlusion by pronounced facets for *M. sternohyoideus* only 2mm apart. This may reflect remodelling following medial displacement of both clavicles in early life. The individual may have appeared hunched and round-shouldered in life, possibly with arm disability.

Figure 106. Manubrium IS(<u>6138</u>): exhibiting dysplasia superiorly (articular facets arrowed).

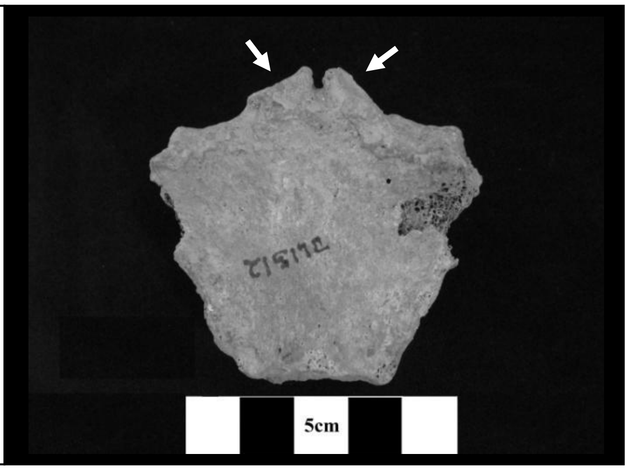


Table 133. Activity-related Pathology of the Clavicle at Isbister.				
Lesion and location	**Number of Cases and Prevalence**			
	Left side		**Right side**	
Pitting at attachment of *L. costoclavicularis*	3/21	14.3%	3/12	25%
Porosity on sternal facet	6/21	28.6%	5/12	41.7%
Porosity on lateral facets	4/43	9.3%	2/25	8.0%
Cyst at attachment of *L. costoclavicularis*	1/21	4.8%	1/12	8.3%

Laterality is suggested in the disparity between figures for observations regarding the medial part of the clavicle. The prevalences could reflect right-handedness in a population that suffered considerably from degenerative conditions but are not significantly different (p=0.44). It was noted that the attachment site of *M. pectoralis major* in the clavicles was well formed in most cases but that rhomboid fossa was rare.

No scapulae exhibited obvious evidence of activity but they were particularly fragmentary and underrepresented and humeri exhibited degenerative conditions.

Table 134. Activity-related Pathology in the Humerus at Isbister.					
Condition	**Child**	**Adolescent**	**Young adult**	**Adult**	**Total**
Proximal enthesophytes	0	0	0	1	1
Distal enthesophytes	0	0	0	4	5
Proximal DJD	0	0	3	24	29
Distal DJD	0	0	0	9	9
Septal aperture	0	1	0	6	7
NB in this and later tables, conditions are listed according to likely cause.					

Age-relatedness and laterality of each condition were examined for sided adult fragments, using estimates of prevalence calculated from the zonation system.

Table 135. Prevalence and Laterality of Recorded Conditions in the Humeri from Isbister.					
	Left		**Right**		**Evidence of Laterality**
Condition	**Records**	**Prevalence**	**Records**	**Prevalence**	
Proximal enthesophytes	0	0	1	3.1%	None
Distal enthesophytes	2	3.7%	2	3.3%	None
Proximal DJD	8	33.3%	10	32.3%	None
Distal DJD	5	9.4%	4	6.6%	None
Septal aperture	5	9.3%	1	1.6%	**Yes**

Most of the conditions in this case clearly occur evenly on either side, which may reflect symmetrical arm use. The only exception is the septal aperture, which might be related to hyperextension at the elbow. If it is assumed that the Isbister population was predominantly right handed in the same proportions as modern societies, then the sided prevalences of this feature are appropriate to use of the passive arm as a support during activity.

Radii

Table 136. Age Distribution of Activity-related Pathological Conditions in the Radius					
Condition	**Child**	**Adolescent**	**Young adult**	**Adult**	**Total**
Enthesopathy	0	0	1	9	11
Trauma	0	1	0	4	5
Proximal DJD	0	0	0	2	2
Distal DJD	0	0	0	9	9

Laterality of each condition was examined, using only the sided adult fragments and estimates of prevalence from the zonation system (Table 137). A higher prevalence of distal DJD on the right side may reflect handedness associated with an activity involving wrist use but that is not reliant on the elbow. The limited evidence of traumatic conditions probably reflects the accidental nature of falling injuries resulting in fractures. There is no obvious pattern to the location of DJD except the increased prevalence on the right side distally. The relationship of age to DJD is consistent with its progressive nature.

Table 137. Prevalence and Laterality of Recorded Conditions of the Radius

	Left		Right		Evidence of Laterality
Condition	**Cases**	**Prevalence**	**Cases**	**Prevalence**	
Enthesopathy	5	16.7%	6	15.8%	None
Trauma	1	1.3%	3	3.9%	None
Proximal DJD	1	3.7%	0	0	None
Distal DJD	2	4.3%	7	17.9%	**Yes**

Complexity of the distal articulations permits further definition of location (Table 138) but small sample size inhibits interpretation beyond noting that right radii are more affected (χ^2=6.79, p<0.01), which may reflect handedness.

Table 138. Location and Laterality of DJD on the Radius

Side	**Distal Articulation**			**Proximal Articulation**
	Medial	**Lateral**	**Both**	
Left	1	0	1	1
Right	4	2	1	0

Carpus and Manus

IS(3443) is a right lunate with the articular facet for the triquetral eburnated dorsally. No other carpal exhibited DJD or related conditions but relatively few carpals were identified in the assemblage.

Table 139. Prevalence and Laterality of Recorded Conditions of the Metacarpals from Isbister.						
		Left		Right		Laterality?
Bone	Condition	Cases	%	Cases	%	
MC1	**Enthesopathy**	0/21	0	1/19	5.3	No evidence
	Trauma	1/20	5	0/20	0	No evidence
	Proximal DJD	1/20	5	1/19	5.3	No evidence
	Distal DJD	4/21	19	2/19	10.5	None: p=0.42
MC2	**Enthesopathy**	0/30	0	0/31	0	No evidence
	Trauma	0/19	0	1/23	4.3	No evidence
	Proximal DJD	0/30	0	1/31	3.2	No evidence
	Distal DJD	0/27	0	0/26	0	No evidence
MC3	**Enthesopathy**	0/31	0	0/34	0	No evidence
	Trauma	0/23	0	0/19	0	No evidence
	Proximal DJD	1/31	3.2	0/34	0	No evidence
	Distal DJD	1/31	3.2	1/33	3	No evidence
MC4	**Enthesopathy**	0/19	0	0/18	0	No evidence
	Trauma	0/18	0	0/18	0	No evidence
	Proximal DJD	0/19	0	0/17	0	No evidence
	Distal DJD	0/19	0	0/16	0	No evidence
MC5	**Enthesopathy**	0/13	0	0/22	0	No evidence
	Trauma	0/11	0	3/19	15.8	None: p=0.28
	Proximal DJD	0/12	0	0/22	0	No evidence
	Distal DJD	3/13	23.1	6/22	27.3	None
Prevalences were calculated based on having sufficiently complete elements for presence/absence to be evaluated.						

IS(6201) (Figure 107) is a metacarpal, probably the first. The epiphysis is absent and the metaphyseal surface is highly porotic, with nodules of new bone forming around the margins. There is another 1mm bone nodule palmarly on the distal articular surface. The condition of the proximal metaphysis may be due to inflammation of the physis. This could possibly relate to the lesion noted in IS(3638) (see p323).

Figure 107. IS(6201), proximal aspect.

Table 140. Pathological Conditions of the Manual Phalanges from Isbister.					
Condition	**Proximal, first ray**	**Proximal other**	**Intermediate**	**Distal**	**Uncertain**
Enthesopathy	0	2	0	0	0
Fracture	0	1	0	0	0
Proximal DJD	1	1	1*	1*	0
Distal DJD	0	0	2*	0	0
Palmar groove	2	6	0	0	1
* ankylosed phalanges					

Pathological conditions are rare in the manual phalanges but the sample is small. The frequency of palmar grooves is striking (prevalence rate is estimated at 5.8% for proximal phalanges). This condition arises from continued hyperflexion, possibly related to local paralysis but probably behavioural in most cases. IS(3568) is a distal manual phalanx with a porotic articular surface; its palmar aspect is markedly flat. This is likely to be a case of degenerative joint disease in which flexion of the interphalangeal joint is implicated as a factor. Figures 108 and 109 show other phalangeal abnormalities.

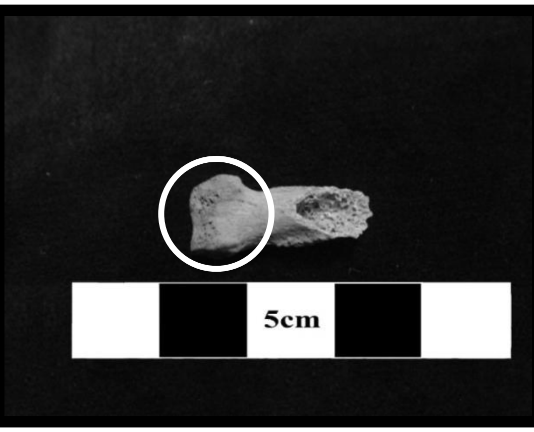


Figure 108. IS(3568), palmar aspect, head flat.

Figure 109. IS(3460), dorsal nodule.

IS(7151) consists of 2 fused manual phalanges: the distal and intermediate (Figure 110). The distal phalanx is angled at about 20º laterally to the axis of the intermediate phalanx but is coplanar coronally. The proximal epiphysis of the intermediate phalanx is cup-shaped and pitted, with marginal bone spicules. This strongly suggests a seronegative arthropathy. This has the classic appearance of psoriatic arthritis but other conditions, especially erosive OA and rheumatoid arthritis cannot be satisfactorily ruled out.

Figure 110. IS(7151): ankylosis of distal interphalangeal joint (DIP)

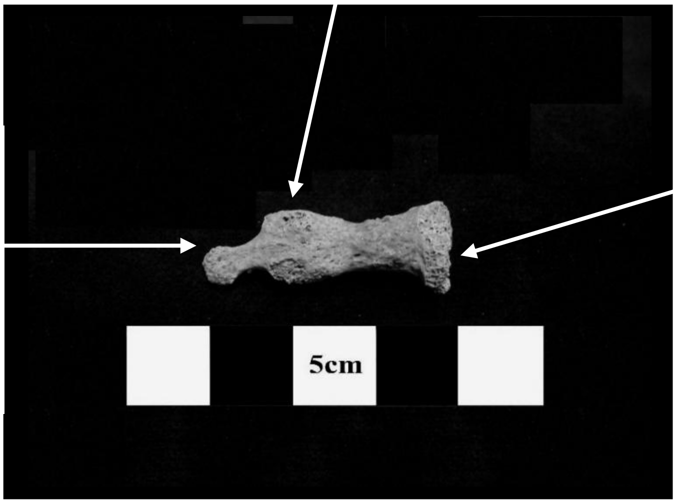
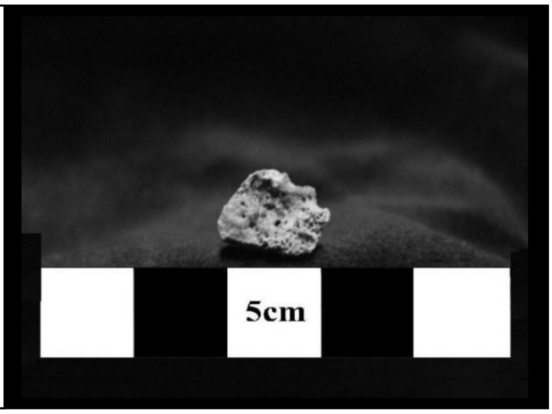


Table 141. Differential Diagnosis of IS(7151) Phalanges. (Inconsistent features shaded.)							
Symptom	**PA**	**Reiter's disease**	**AS**	**Entero-arthropathy**	**RA**	**Erosive OA**	**Leprosy**
DIP joint affected	**Y**	Y	N	Y	Y	Y	Y
PIP joint affected	**Y**	Y	N	Y	Y	Y	N
Enthesopathy	**Y**	Y	Y	N	Y	Y	N
Cup and pencil form	**Y**	N	N	N	Y	N	N
Upper limb	**Y**	N	Y	Y	Y	Y	Y
Ankylosis	**Y**	Y	Y	Y	Y	Y	Y

Figure 111. IS(7151), Proximal aspect, showing porotic, cup-shaped proximal articular surface with peripheral spiculated bone growth



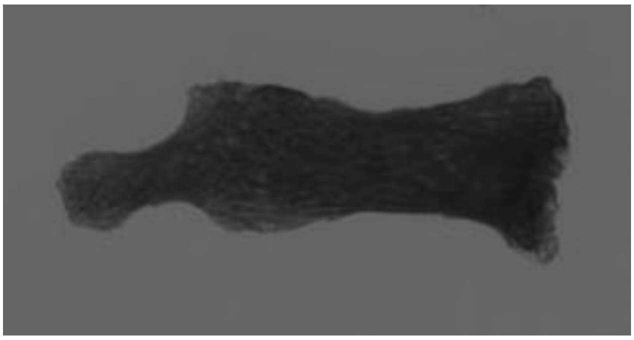


Figure 112. Radiograph of IS(7151), showing well healed ankylosis, 'fluffy' peripheral bone and absence of pyogenic lesions.

Ossa Coxae

Table 142. Activity-related Pathological Conditions of the Ossa Coxae from Isbister.			
Condition	**Left**	**Right**	**Total**
Enthesopathy at iliac crest	0/21	1/31	1/58
Enthesopathy at ischial tuberosity	1/70	0/72	1/144
DJD at sacroiliac joint	0/59	0/69	1/136
DJD at acetabulum	11/83	11/77	24/164

IS(2916) (Figure 113) is a right os coxae fragment with new bone deposits viscerally on the inferior ilium and around the acetabular fossa, where a raised annular roseate plaque has formed extending 17mm from the fossa with a height of 3mm. The acetabulum also has thick porous woven bone inferior to and contiguous with the annular feature and a thinner deposit of rounded nodules inferiorly on the limbus. The iliac deposit is too truncated by damage to permit any detailed description but, at over 1mm in thickness, is likely to have been significant. The acetabular features seem likely to relate to a degenerative condition of the joint. The acetabular bone growth could be a benign neoplastic condition limited by neighbouring tissues but seems more likely to reflect remodelling after trauma. About 14% ossa coxae from Isbister had DJD in this location (Table 142 above), which may support an activity-related aetiology.

Figure 113.
Acetabulum IS(2916), exhibiting bone plateau.

Femora

Table 143. Activity-related Pathological Conditions in the Femora from Isbister.					
Condition	**Child**	**Adolescent**	**Young adult**	**Adult**	**Total**
Enthesopathy	1	1	0	5	7
Bone adaptation at medial head of *M. gastrocnemius*	0	1	0	28	30/142
Intercondylar bone alteration	2	0	0	14	16/133
OD or subchondral cysts	0	1	0	7	8/133
Proximal DJD	0	0	0	34	37/139
Distal DJD	1	0	0	45	47/133
NB Totals include those fragments for which no age attribution was made.					

Figure 114. Remodelling at the *M. gastrocnemius* attachment site of femora. (Note also DJD on articular surfaces.)

Figure 115. Florid bone deposition: OA of the distal femur (lateral and posterior aspects).

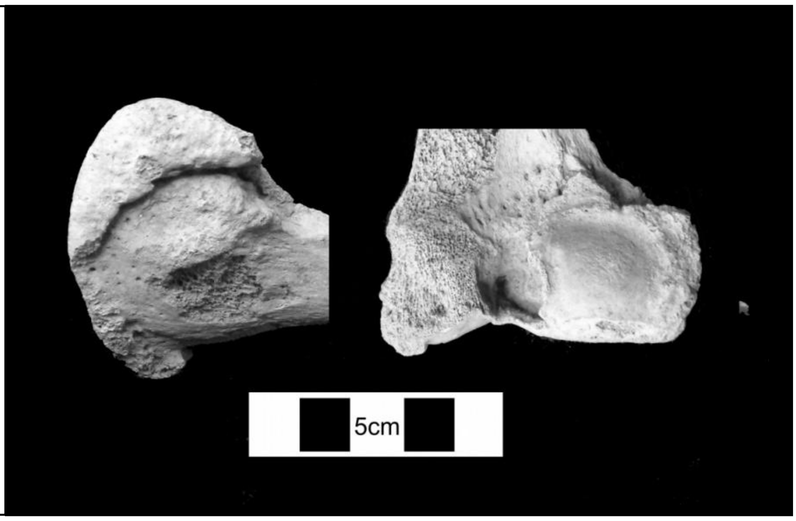


Table 144. Prevalence and Laterality of Recorded Conditions in Adult Femora from Isbister.					
Condition	**Left**		**Right**		**Laterality**
	Records	**Prevalence**	**Records**	**Prevalence**	
Enthesopathy	5	3.8%	0	0	**Yes**
Bone adaptation at medial head of *M. gastrocnemius*	19/58 (zone 8)	32.8%	9/50 (zone 8)	18.0%	Slight X^2=3.046, p=0.08
Intercondylar bone alteration	9/57 (zone11)	15.8%	5/56 (zone11)	8.9%	None
Osteochondritis dissecans	2	2.7%	5	7.9%	Slight
Proximal DJD	14/45 (zone 4)	31.1%	17/54 (zone 4)	34.7%	None
Distal DJD	23	30.7%	21	33.3%	None

Most activity-related pathological femoral conditions (Table 144) occur more frequently on the left side, which may reflect handedness but differences are generally statistically insignificant. Enthesophytes were only recorded on left femora, which may reflect greater incidence of strain and trauma on that side but aetiologies are uncertain. Metric study of the femoral neck suggested indicate greater relative robusticity of the right side and this suggests that, although activity may be related, underlying mechanical factors were complex. Nine right and eight left femoral necks from Isbister exhibited bone plaques, at least six were woven bone associated with DJD; others may be Poirier facets.

<u>*Patellae*</u>

Vastus notch and fossa were more prevalent on the left side (43.6% left had both, 12.8% neither vs. 29.5% both, 22.7% neither right). Enthesopathy of the patellae was rare and minor but again more prevalent on the left (14% vs 4.5%).

Tibiae

Laterality of each condition in the tibiae was examined, using only the sided adult fragments and estimates of prevalence from the zonation system (Table 145). Correlation between proximal DJD and new bone formation at the tibial tuberosity was also examined, using adult fragments where the proximal end was nearly complete (i.e.. zones 1,2,3,4 and 7 were all recorded as present).

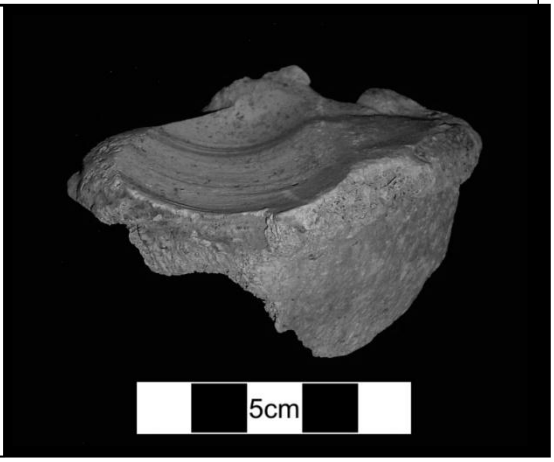
Table 145. Prevalence and Laterality of Recorded Conditions in the Tibiae from Isbister.

	Left		**Right**		**Evidence of Laterality**
Condition	**Cases**	**Prevalence**	**Cases**	**Prevalence**	
Proximal enthesopathy	3	4.4%	0	0	**Yes**
Distal enthesopathy	1	1.7%	1	1.9%	None
Extended condylar surface	1 *	1.6%	0*	0	None
Osteochondritis dissecans	1	1.6%	1	1.6%	None
Trauma	4 *	3.2%	0	0	N/A?
DJD at fibula	4	6.3%	2	3.2%	None
Proximal DJD	4	6.8%	5	10.2%	None
Distal DJD	3	5.1%	2	4.1%	None
Squatting facet	27	45.8%	26	53.1%	None

NB *Trauma includes two cases each of avulsion of intercondylar tubercles and fracture.

Figure 116.

Proximal eburnation of tibia IS(NMS23).



Tibial enthesophytes were only observed on the left side but this may reflect the incidence of avulsion and fracture only on that side; similarly, the higher prevalence of DJD on the left fibular articular facet may be due to increased trauma on that side. This echoes enthesopathic laterality of the femora however, suggesting some common factor exposing the left lower limb to harm.

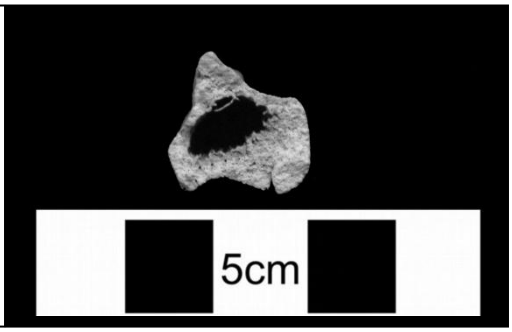
Fibulae

Table 146. Prevalence and Laterality of Recorded Conditions of the Fibulae from Isbister.

	Left Side		**Right Side**		**Evidence of Laterality**
Condition	**Cases**	**Prevalence**	**Cases**	**Prevalence**	
Distal enthesopathy	1	5.3%	1	5.0%	None
Bone change at interosseous membrane	1	2.2%	3	6.1%	None
Bone change at talofibular ligament	2	4.4%	5	10.4%	None
Proximal DJD	1	5.3%	2	10.0%	None
Distal DJD	1	2.2%	1	2.1%	None
Haematoma	0	0	1	2%	None

Most fibular conditions clearly occur evenly on either side, which may reflect equal sided use. A distinctive feature of the fibulae was their deeply indented cross-section (Figure 117): Hrdlička's type 3b, affecting all major surfaces (Hrdlička1947:176-7). This reflects highly developed leg musculature.

Figure 117. Typical fibular mid-diaphyseal cross-section, showing deep indentations from musculature (see Hrdlička 1947:176-7).



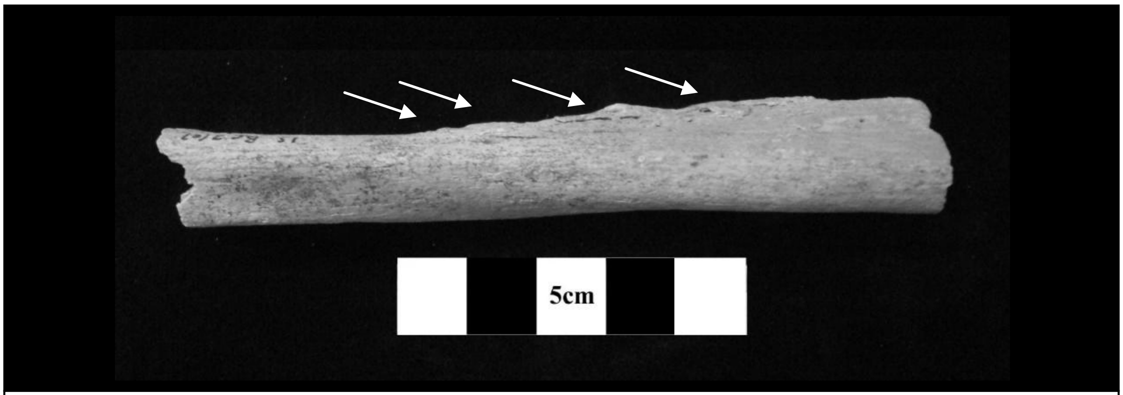


Figure 118. Fibula diaphysis with superimposed localised layers of new bone, probably indicating successive episodes of healing and suggesting repeated injury.

Tali

Most tali had suffered from marginal damage that made them difficult to assess. Accessory contact facets for the tibia were found on nine, of which two were left sided (from 77) and seven right (from 64). Osteoarthritis was observed on eight tali: three left and five right, in three instances on all articular surfaces of the bone and once on two surfaces. Overall, the calcaneal and navicular articulations were involved six times each but the tibial only in three instances – and only when both other articulations were also affected.

Talus IS(4702) appears to exhibit a well healed crush fracture (Figure 119).

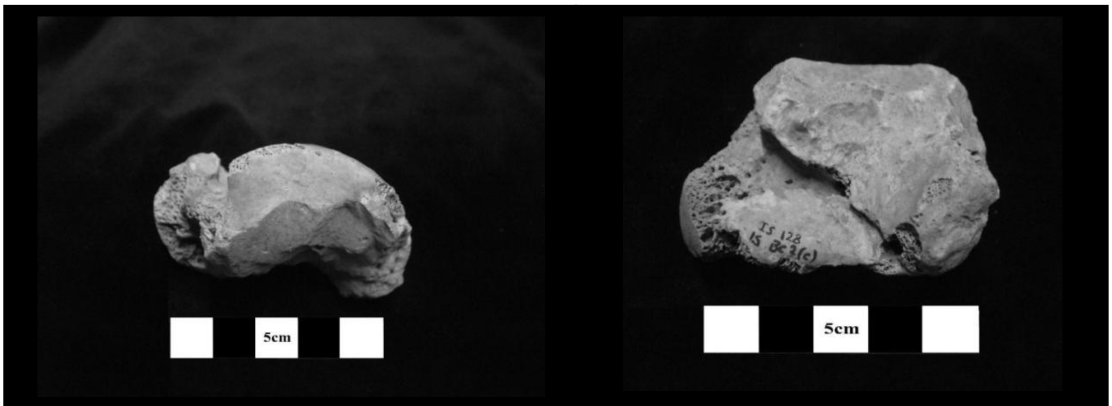
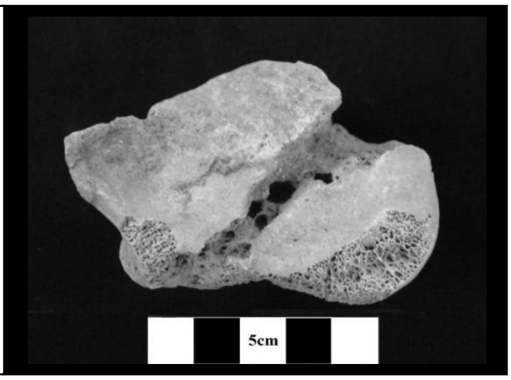


Figure 119. Talus IS(4702), lateral and inferior aspects.

Figure 120. Talus IS(<u>5816</u>), inferior aspect, showing cyst formation and interarticular bone deposition.



<u>Calcanei</u>

Osteoarthritis was observed to occur on calcanei at each articular surface, with a slightly greater prevalence on the right side talar articulations. Seventeen cases were found, equally distributed by side, with entheses for *T. Achilles* but these were mild; six cases were found with bands of porosity at the surface for the posterior bursa, possibly indicating bursitis. Six cases, three from each side, were interpreted as displaying widespread periostitis; and thirty-two other cases, evenly distributed by side, were found to have localised periosteal bone formation indicative of a non-specific pathological condition. New bone was observed in all stages of formation from porous woven bone, through striate woven and cortical bone to fully remodelled bone plaques. The most common location for such new bone was inferolaterally in an area bounded by the attachments of the tarsal ligaments and retinaculum (Figure 122). This area has little soft tissue protection during life and the observed formation may most likely be due to an inflammatory periosteal reaction to trauma. The prevalence of this condition is such that it implies commonly inadequate foot protection or excessive stress. The individuals may have suffered frequent tenderness of the heel that could have made walking uncomfortable, resulting in altered gait (there is some resonance here with the cases of coxa vara described above).

Table 147. Prevalence of Pathological Conditions of the Calcanei from Isbister.					
Condition	**Right Side** n=66		**Left Side** n=63		**Laterality**
	Cases	**Prevalence**	**Cases**	**Prevalence**	
Entheseopathy at *T. Achilles*	8	12.1%	8	12.7%	None
Possible bursitis	4	6.1%	2	3.2%	None
Inferolateral periostitis	16	24.2%	16	25.4%	None
Osteoarthritis (cuboid)	1	1.5%	1	1.6%	None
Osteoarthritis (talus)	4	6.1%	2	3.2%	None
There is no apparent laterality in the prevalence of pathological conditions.					

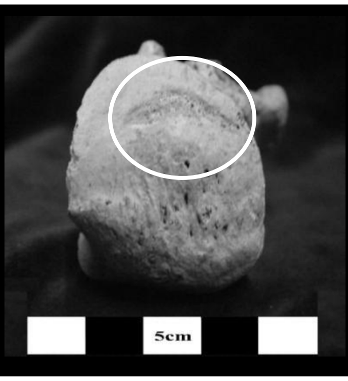


Figure 121. Pitting (L) and porosity (R) of the posterior calcaneus: possibly related to either *T. Achilles* or the bursa superiorly.

Figure 122. Inferolateral woven bone on a calcaneus, possibly traumatic in origin.

Metatarsals

Table 148. Activity-related Pathological Conditions of the Metatarsals from Isbister.						
MT	**Side**	**Enthesopathy**	**Cyst**	**Fracture**	**Proximal DJD**	**Distal DJD**
?	**?**	0	0	0	0	2=5.1%
MT1	**L**	1=2.6%	2=6.3%	1=3.0%	1=3.1%	6=18.8%
	R	1=2.4%	0	1=3.0%	1=3.0%	2=5.4%
	?	0	0	0	0	1=20.0%
MT2	**L**	0	0	0	1=2.9%	4=20%
	R	0	0	0	0	1=5.9%
MT3	**L**	0	0	0	0	0
	R	0	0	0	0	2=8.7%
MT4	**L**	0	0	0	1=3.2%	2=14.3%
	R	0	1=3.2%	0	0	1=5.9%
MT5	**L**	0	0	2=8.0%	0	1=6.3%
	R	0	0	1=4.0%	0	2=10.5%

Degenerative conditions of the metatarsals (Table 148) are clearly more prevalent on the left than on the right side and all pathological conditions except fracture occur with greatest frequency in the first metatarsal. Fractures occur more frequently in the fifth metatarsal, probably because it is relatively unprotected on the lateral edge of the foot and is less robust than the first. Osteoarthritis was particularly common in the first metatarsal, affecting both articular surfaces, but especially the plantar region of the distal articulation, which frequently displayed eburnation. Simple pitting of the distal articular surfaces (Figure 123) was included in the figures for DJD but may have alternative aetiologies including disuse atrophy and osteoporosis.

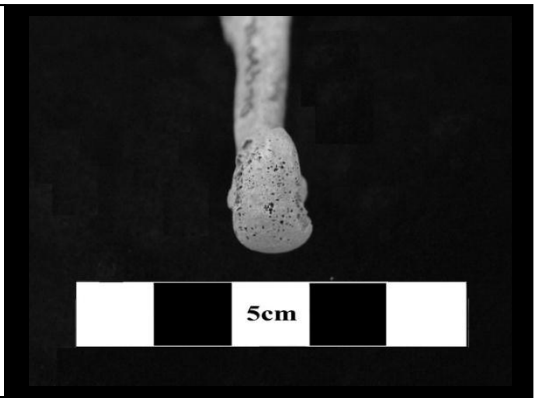


Figure 123.
Pitting of the distal articulation was common on metatarsals.

IS(5006), (5002), (5000) and (4996) are proximal fragments from four adjoining right metatarsals (second through fifth) from a single individual (indicated by their close fit and pattern of degenerative porosity, see Figure 124). This is clearly osteoarthritis centred on the tarsometatarsal joint but the difference in the condition of the co-articulating facets of MT3 and MT4 is remarkable. The MT4 facet has become eburnated without apparently affecting MT3 against which it was presumably rubbing. It is possible that there was loose material in this joint that caused this abrasion.

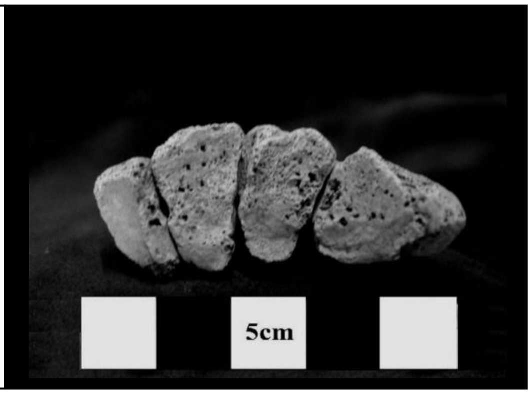


Figure 124. Pitted proximal epiphyses of four metatarsals, articulated:
IS(5006), (5002), (5000) and (4996).

Despite the absence of significant bone formation or eburnation, this pattern is suggestive of a well-advanced degenerative condition in this individual, which may have made walking awkward or painful but could have been asymptomatic.

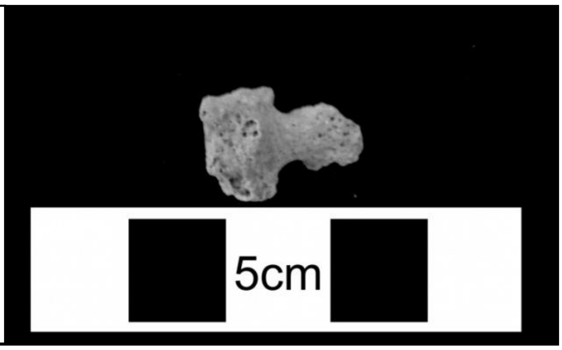
Pedal Phalanges

Table 149. Activity-related Pathological Conditions of the Pedal Phalanges from Isbister.					
Condition	**Proximal, first ray**	**Proximal**	**Intermediate**	**Distal**	**Uncertain**
Enthesopathy	0	2 (4.8%)	0	0	0
Cyst	1 (3.2%)	1 (2.4%)	0	0	0
Dysplasia	0	1 (2.4%)	0	0	0
Ankylosis	0	0	2* (33.3%)	2* (50%)	0
Proximal DJD	5 (20%)	0	0	0	0
Distal DJD	0	2 (5.7%)	0	0	0
Plantar groove	3 (12%)	0	0	0	0
* marks two ankylosed phalanges in each instance					

The prevalence for phalangeal ankylosis (Table 149, Figure 125) seems high but such phalanges were more noticeable (relative to single intermediate or distal phalanges) and recognisable due to this condition. There are no indications on these bones of any particular pathological process that might have caused this ankylosis.

Plantar grooves on the first phalanx (Table 149, bottom row) were only observed on the first ray. They are related to plantarflexion and presumably activity related, possibly from supporting objects with the foot.

Figure 125.
IS(1565): an example of fused medial and distal pedal phalanges (of two identified).



Skeletal Conditions at Banks

DJD and OA

DJD was observed to be particularly severe in two anatomical locations – the neck and the jaw, although minor pitting was widespread.

Several temporomandibular joints exhibit DJD (e.g. Figure 126). Two mandibles (BSR(107) and BSR(1380), both young adults) exhibit slight pitting of the condyles and one mandible (BSR(1359)) exhibits severe bilateral DJD with pitting, flattening and eburnation of the articular surface, together with marginal osteophyte growth. Five cranial fragments BSR(642), BSR(724), BSR(917), BSR(1179) and BSR(1618) exhibit remodelling of the anterior eminence of the mandibular fossa. In the case of BSR(1618), this remodelling is sufficiently severe to include the anterolateral part of the inferior sphenoid. Severe cases, such as BSR(1359) and BSR(1618), have caused disability in jaw use.

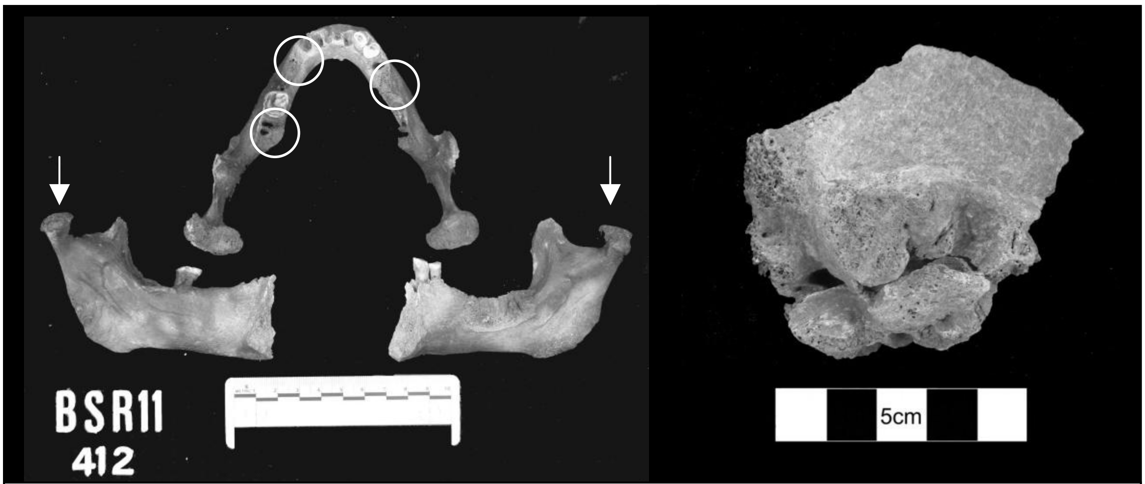


Figure 126. TMJ Remodelling. Mandible BSR(1359) (left) has severely remodelled eburnated condyles (arrows) (note ante-mortem tooth loss, periodontal disease (circled)). Sphenoid and temporal BSR(1618) (right) is severely remodelled at the mandibular fossa.

TMJ DJD may most likely result from trauma or non-masticatory jaw use i.e.

using the mouth as an extra hand or tool, for example in preparation of skins or fibres. The presence of an incisor with an occlusal notch labially (BSR(562)) may be relevant in this respect, as an indicator of such non alimentary activity.

Figure 127. Cervical vertebra BSR(1506). Eburnation of the right articular facet, indicates osteoarthritis of the neck. The left facet is enlarged and angled differently from the right, possibly a related feature.

In at least two individuals, there was severe degeneration of vertebral joints of the neck, including eburnation, pitting and joint form remodelling (e.g. Figure 127). Only 21 adult cervical vertebrae were recorded, potentially representing just three individuals. Only eight of these vertebrae did not exhibit degenerative lesions but most of those were too damaged for a definitive assessment. Pitting and ‘lipping’ were common. Pits and entheses were recorded at ligament and tendon attachment sites and in one individual are probably secondary to a cervical crush fracture (pp331-2 below). Eburnation, exhibited in two individuals, is a more significant feature and likely to indicate abnormal structure or excessive joint use.

Less severe DJD was observed in the thoracic and lumbar regions. In the adult thorax, pitting and lipping typically affected articulations between vertebrae and ribs, which may indicate a mechanical cause but could be age related.

Relatively few vertebrae exhibited lipping at the body margins. In the cases of

BSR(1490) and BSR(1534), this lipping was quite florid and associated with a degree of anterior ramparting.

Sacralisation of the 5th lumbar vertebra was observed in BSR(1365) (Figure 128). This sacrum was fully fused to the lumbar vertebra on the left side, with a probable cartilaginous joint at the right ala, and the vertebral bodies retained a normal disc space. This condition resulted in a marked asymmetry of the superior vertebral surface and asymmetry of the spinous process. Posterior lesions on the sacrum are likely to be associated with ligamentous attachments acting disadvantageously and becoming chronically damaged. There is little indication of any other ongoing bone remodelling and so this is a long-standing condition and may be considered congenital (see p263 above), although it is possible that it has its origins in early life. It is described here because it is likely that asymmetry of the superior articulations (Figure 128 top left) will have resulted in mechanical instability of the lumbar vertebrae and would have been a potential cause of degenerative joint disease and lower back problems.

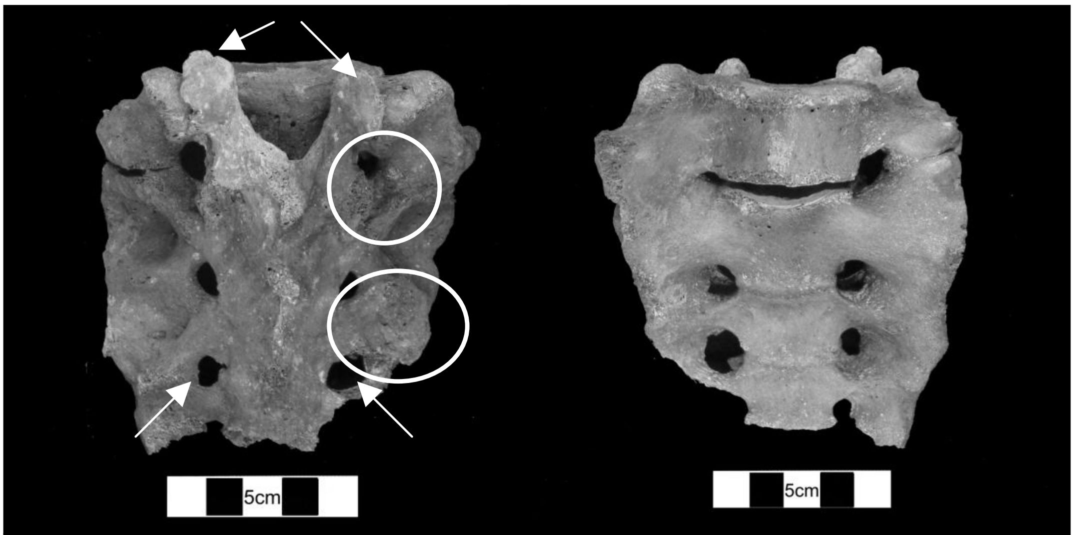


Figure 128. Sacrum BSR(1365): sacralisation of the fifth lumbar vertebra, associated with remodelling at soft tissue attachment sites (circled) and other asymmetry (arrows).

Figure 129. Thoracic vertebra BSR(1534), exhibiting lipping of the left superior facet and body, there is misalignment of the articular facets, indicating abnormal articulation.

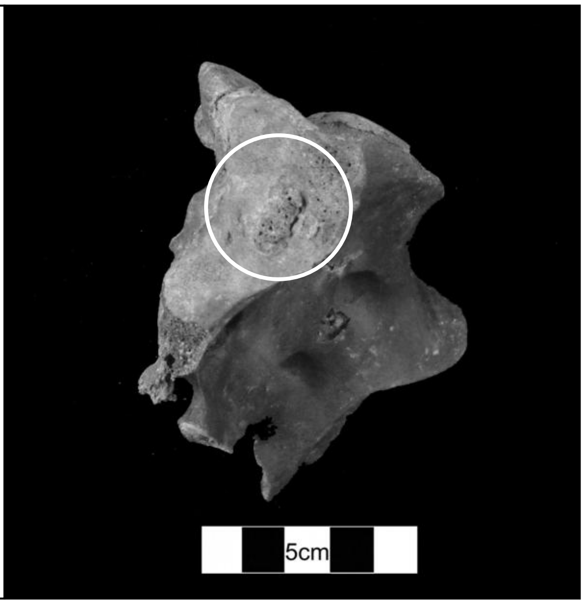
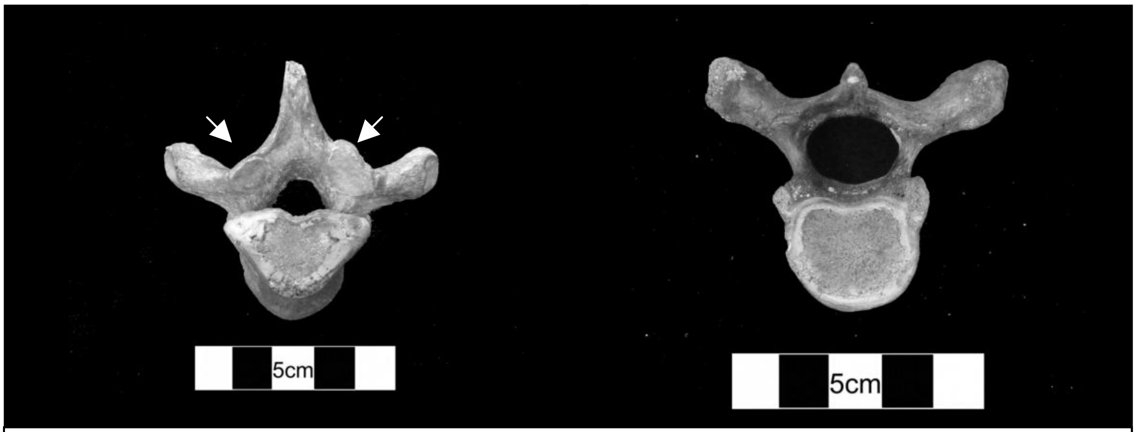


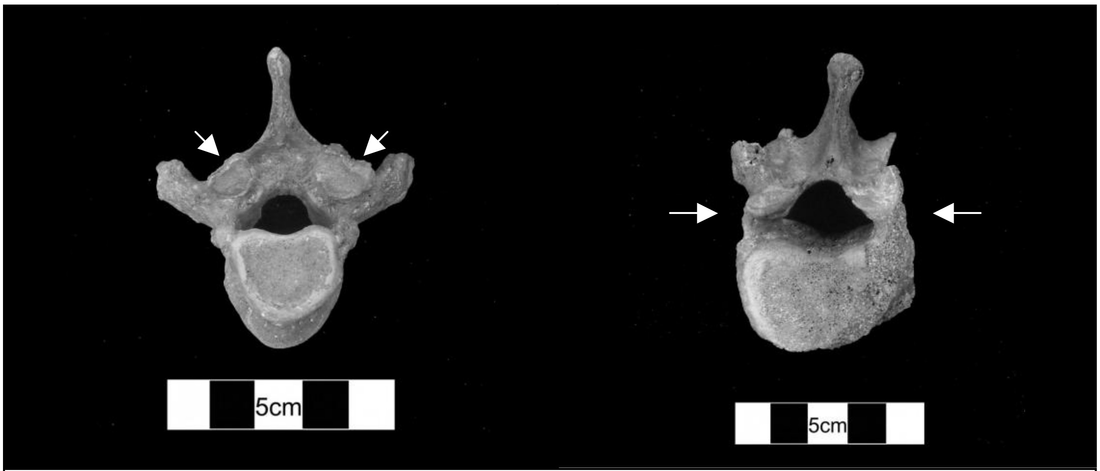
Figure 130. Sacrum BSR(350) shows remodelling on the auricular surface, possibly indicative of damage to the sacroiliac joint.

Several vertebrae show signs of asymmetric development or DJD. These may reflect asymmetric activity patterns rather than pathology directly.



BSR(853): asymmetric articulations BSR(1220): asymmetric DJD

Figure 131. Examples of vertebral asymmetry.



BSR(1232) asymmetric DJD BSR(1265) asymmetric articulations

Figure 132. Further examples of vertebral asymmetry and DJD.

Clavicle BSR(1339) (Figure 133) exhibits gross remodelling of the medial articular surface, with joint expansion and pitting, probably associated with the enlargement of the rhomboid fossa.

Figure 133. Clavicle BSR(1339), showing DJD of the medial epiphysis (B) and an enlarged fossa for the costoclavicular ligament (A).

The left example in Figure 134 is a distal humerus with pitting of the capitulum, indicating that the elbow was affected; the right example is a distal metatarsal with a pitted head showing that the toe was affected.

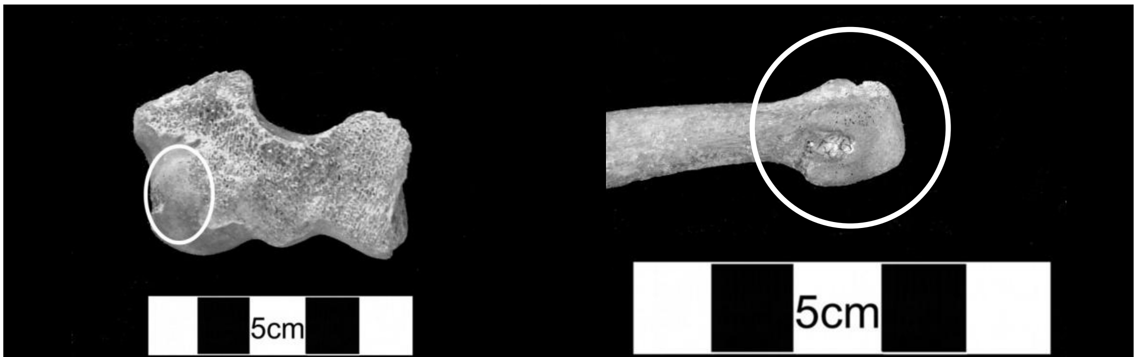


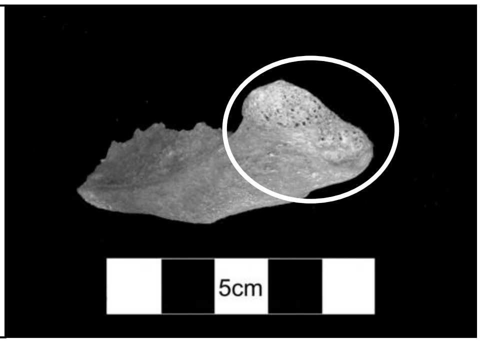
Figure 134. Other examples of degenerative joint disease (described above).

Virtually all joint types were affected by DJD but pitting at articular surfaces of longbones, ossa coxae, scapulae and the bones of hands and feet was generally minor. These cases may have been asymptomatic but are indicators of a widespread decay of joint cartilage in the population that suggests generally hard working loads on the joints.

It is likely that the Banks cases of DJD came from a small number of individuals, each with multiple lesions. The small number affected has potentially greater significance when the limited number of individuals assessed is taken into account, along with the generally young age distribution. Thus it seems probable that at least two out of three adult necks had severe DJD. It would have been useful to examine the occipital condyles of crania to find whether these were involved but these areas have been mostly lost in this assemblage.

Musculoskeletal Activity Markers at Banks

Figure 135. Scapula BSR(1467), exhibiting a pitted pseudarthrosis caused by *os acromiale*.



Four femora exhibit an ovoid pit posteriorly towards the medial margin at the distal end of the diaphysis, probably related to the attachment of either the *vastus medialis* or *adductor magnus* muscles (most likely the former): it is too high to relate to m. *gastrocnemius*. This probably indicates heavy working of the muscle, leading to the formation of a larger attachment area for increased strength. Observed in both adults (one) and juveniles (three) at Banks, this may relate to the pathological appearance of the attachment site for the medial head of the *gastrocnemius* muscle observed on femora; itself sometimes a very clearly formed fossa. *M. gastrocnemius* is a flexor of the knee and the *m. vastus medialis* is an extender of the knee, so it is possible that the two are acting as antagonists with particular loading (see Mann and Hunt 2005:173-6).

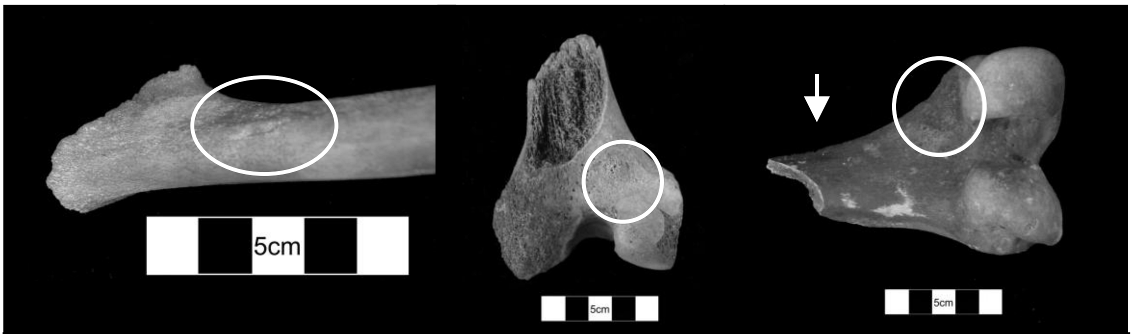


Figure 136. Posterior aspects of three left femora. BSR(1373) (left) is a juvenile femur with a pit for *m. vastus medialis*; BSR(139) (centre) shows pitting for *m. gastrocnemius* (circled), and BSR(707) (right) shows a fossa for the medial head of *m. gastrocnemius* (circled) and a pit for *m. vastus medialis* (arrowed).

Squatting facets were recorded on 50% of both tibiae and tali, equally on both sides. These are indicators of extreme pedal dorsiflexion and could be associated with the femoral MSM above.

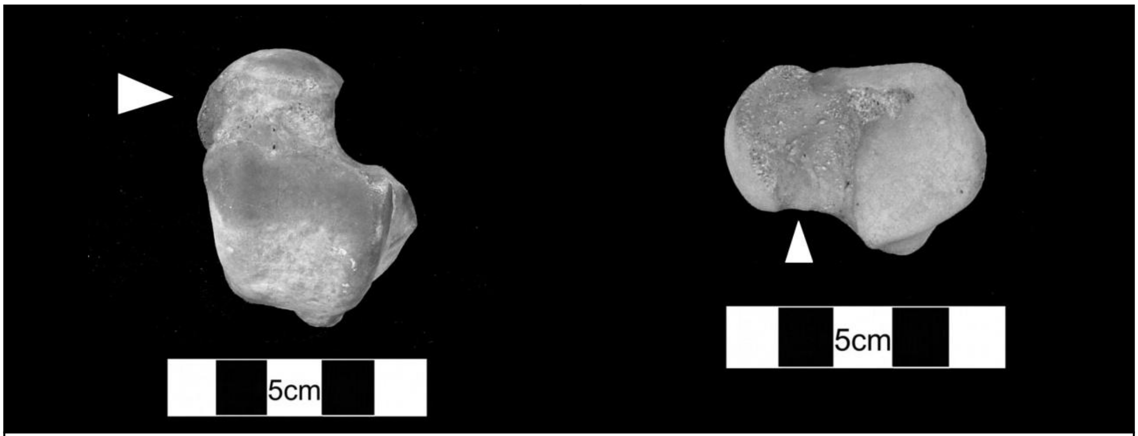
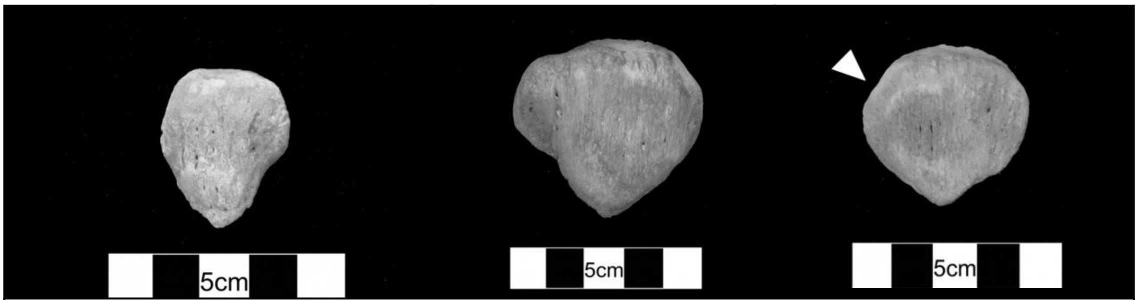


Figure 137. Two tali exhibiting 'squatting facets.'
Left BSR(1258), right BSR(1311).



BSR(394) BSR(1181) BSR(1297)

These three patellae exhibit different features. BSR(394) is abnormally narrow but shows no signs of pathology; BSR(1181) appears to have a healed bipartite fracture, although this could be a developmental abnormality; BSR(1297) is normal but has a good example of vastus fossa/notch.

Figure 138. Variation in patellae from Banks.

Poirier facets (e.g. Figure 139) were rarely recorded in this project: at Banks because of the small number of femora; at Isbister because fragmentation prevented adequate assessment of the femoral neck. This does not imply that they were rare in the populations.

Figure 139. A Poirier facet on femur BSR(887). This is a smooth flattened area caused by habitual strong flexion at the hip

Rousay Tombs

Observations on remains from the Rousay monuments were limited by small sample sizes and are unlikely to be representative. The only DJD recorded was a single case in a TMJ from Knowe of Yarso; absence elsewhere cannot be inferred and there is no adequate means for intersite comparisons including these assemblages.

Table 150. Cases of DJD from Rousay

	Cases observed with severity scores			
Condition	**None**	**Slight**	**Moderate**	**Severe**
DJD at TMJ	Lairo	Yarso		
DJD at occipital condyles				

Summary of Degenerative Joint Disease and Activity Markers

"*Without a doubt there is much evidence of arthritis in [the Neolithic] population.*"

(Brothwell 1973:295).

Degenerative joint disease, including osteoarthritis was discovered throughout the assemblages. Degenerative conditions might be attributable to heavy labour and trauma but it is possible that factors of heredity and disease affected the prevalence of secondary osteoarthritis. There may, for example, be a genetically-linked seronegative arthropathy present in the population: the tentatively identified psoriatic arthritis has a strong hereditary component. It is by no means impossible that other similar conditions, such as ankylosing spondylitis, also exist among the population(s), which may contribute to the prevalence of DJD.

Table 151. Prevalence of DJD and Osteoarthritis in Limb Joints at Isbister.

Joint	Left Side		Right Side	
	OA	DJD	OA	DJD
Shoulder (gleno-humeral)	8.2%	22.4%	3.2%	19.0%
Elbow	4.0%	25.7%	0.7%	10.1%
Wrist	3.0%	10.4%	11.3%	17.7%
Carpo-metacarpal	1.0%	1.9%	0	1.8%
Metacarpo-phalangeal	1.2%	8.4%	3.3%	9.9%
Hip	7.1%	19.1%	5.9%	20.6%
Knee	8.7%	22.4%	9.4%	23.5%
Ankle	1.9%	6.7%	3.1%	10.3%
Metatarso-phalangeal	6.9%	12.9%	0.9%	3.5%
MT1 only proximal	0	3.1%	0	3.0%
MT1 only distal	18.8%	18.8%	2.7%	5.4%

All skeletal regions exhibit osteoarthritis or DJD. This population appears to have died young, so that age is unlikely to be the major factor but prevalences at particular joints and elements indicate behavioural factors in aetiology. A traumatic cause is clear in several instances.

It is difficult to compare most of the DJD results from Isbister study directly with the synthesis of Roberts and Cox, which cites ‘number of joints affected’ or ‘number of individuals affected,’ (Roberts and Cox 2003:72-3). It seems that prevalence at Isbister is generally higher than expected but comparisons might be affected by historic failures to identify dysplastic bones, compounded by fragmentation. The large number of such bones found in supposed ‘animal’ boxes at NMS, and among supposedly faunal material from Point of Cott (Chris Walmsley pers. comm.) is indicative of this. Banks is a difficult to compare because of limited excavation.

Known Neolithic buildings in Orkney were of stone: heavy, cumbersome material. It is probable that the Orcadian Neolithic population was much occupied with land cultivation, including digging, ploughing and carrying fertilisers and crops. These factors could explain the lower limb and spinal arthropathies as well as skeletal development associated with heavy musculature. One discussion noted that OA prevalence increased with the introduction of settled agriculture, patterning showed sexual dimorphism and the elbow was usually the second most commonly affected joint (Bridges 1992:71): increase in traumatic injury associated with warfare could be implicated (Bridges 1992:86).

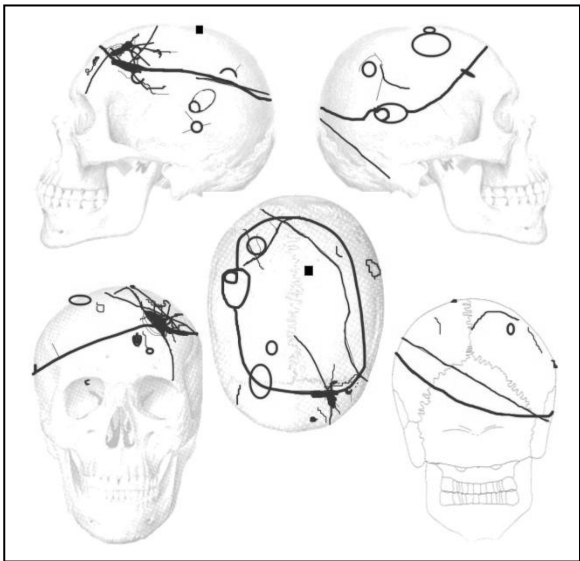
The prevalence figures for OA and DJD show laterality in the increased occurrence in the right wrist, left elbow and left first metatarso-phalangeal joint over the opposite side in both severity categories; involvement of the left shoulder tends to be more severe than the right when it occurs. The left humerus also has a higher prevalence of septal apertures, at 9.3% compared with 1.6% for the right side. These features suggest that activities involved a degree of asymmetry, possibly with common use of the left arm in (over)extension as a brace (Knüsel 2000:109). Rogers did not find DJD in the elbow or wrist in the Hazleton North population nor examples of severe osteoarthritis in any major joint (Rogers 1990:193). This may imply that labour was more strenuous or trauma more frequent in Orkney.

The patterning observed in the bones of the foot seems similar to that observed by Merbs in the Sadlermiut, although he found little laterality of the first metatarsal (Merbs 1983:95ff). The high prevalence of osteoarthritis in the distal left first metatarsal at Isbister is striking; the only statistically significant laterality of tibial pathology is the higher prevalence of left side proximal enthesophytes over right; in the femur, enthesopathy, supratrochlear woven bone and adaptation at the medial head of *M. gastrocnemius* all have higher prevalence on the left side than the right. It seems probable that there is a particular behavioural pattern in the population that causes these effects but curious that the metrical study found greater femoral neck diameters for the right side, presumably indicating greater robustness. There may therefore have been some difference in the resolution of forces through the musculoskeletal complex on either side.

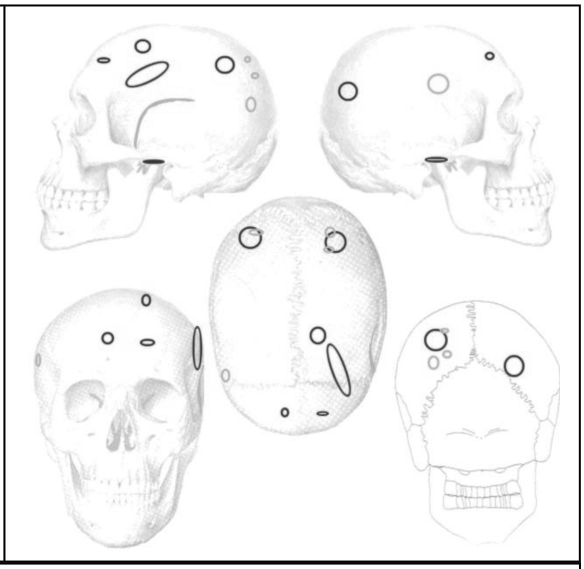
Some particular genetic influence may have contributed to degenerative disease of the temporomandibular joint. It was noticed that many crania had very shallow, often broad, mandibular fossae. This could act as a predisposing factor for subluxation of the mandible. In a population likely to be performing non-masticatory tasks with the jaws, this would increase the prevalence of temporomandibular joint dysfunction. The most severe case of TMJ dysfunction recorded was in an individual that had survived extensive cranial trauma, IS(1973): it is possible that trauma to the mandible occurred simultaneously. With 14 cranial examples of TMJ DJD, Isbister has an adult prevalence of about 32%. This is significantly higher than any population quoted by Roberts and Cox, where the overall prevalence was quoted as 9% (Roberts and Cox 2003:72). This may imply some distinction (cultural or genetic) of the Orcadian population.

Cranial Trauma at Isbister

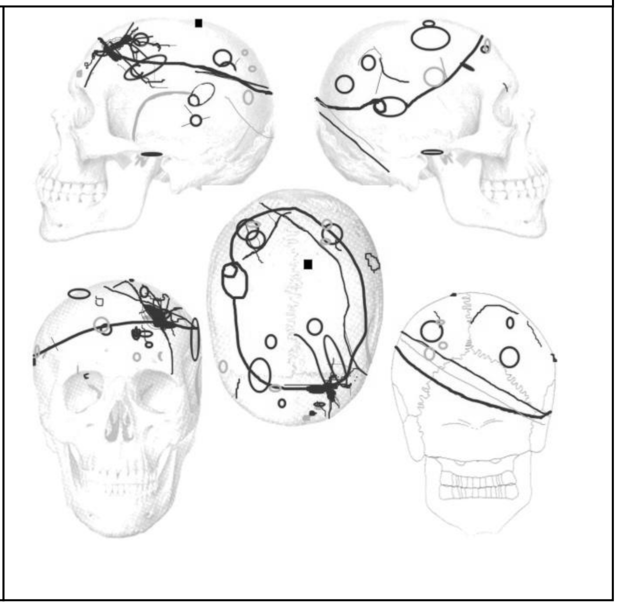
Both healed and perimortem trauma were recorded at Isbister, based on standard criteria (e.g. Galloway 1999; Ortner 2003; Kimmerle and Baraybar 2008). Perimortem trauma was only observed on crania, although, if possible, a full conjoining exercise might have discovered postcranial cases. Healed trauma was exhibited throughout the skeleton.



All perimortem trauma



All healed trauma



All cranial trauma

Figure 140. Cranial trauma recorded at Isbister. Dark: confidently identified, pale: uncertain.

Figure 141.
IS(7207), posterior parts. Bone has been punched out by blunt force trauma to the right parietal; a hoop fracture also resulted.

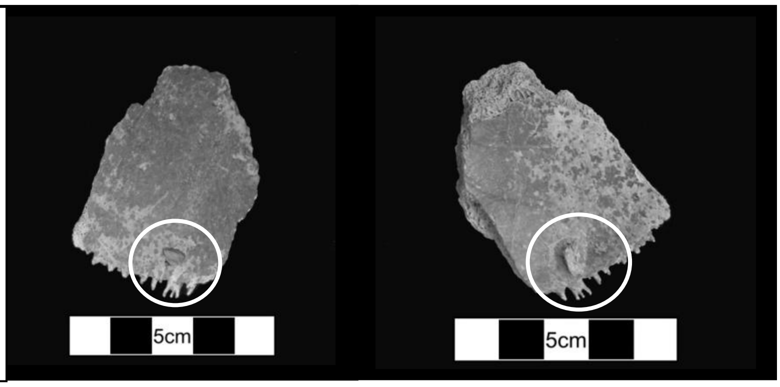


Figure 142. Ecto- (L) and endocranial (R) views of juvenile cranium IS(7114), showing stone embedded (L) and bone spall hinged endocranially (R) as a result.

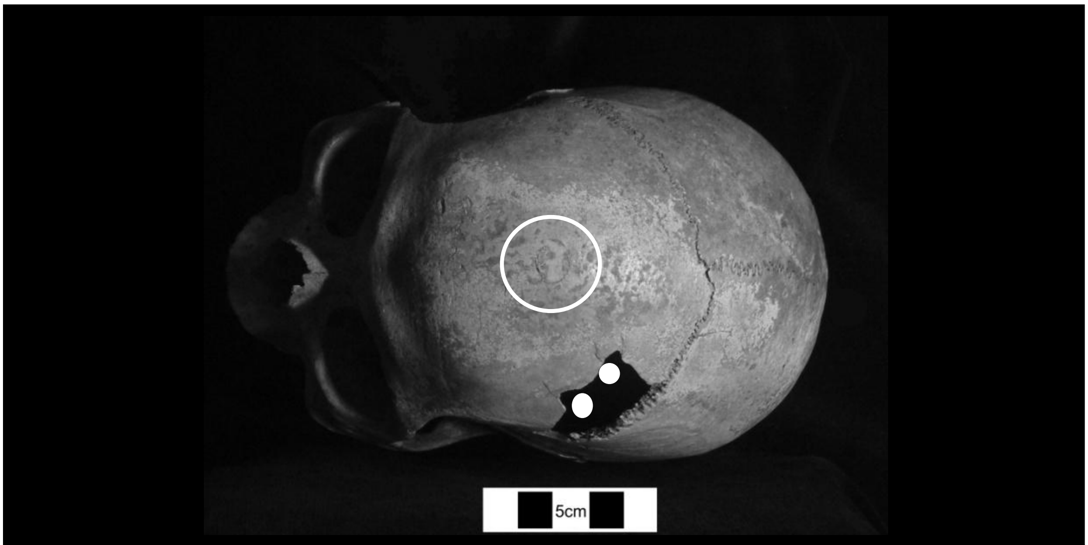


Figure 143. IS(7284). Multiple trauma (with endocranial bevelling and radiating cracks) affecting the left lateral frontal (solid circles) but also a sharply defined circular depressed fracture (with endocranial cracking) medially (circled).

Figures 141-143. Examples of perimortem trauma from Isbister.

Figure 144. Sharp force trauma medially on frontal IS(7280): chatter and spalling (circled) indicates a blow travelling from right to left (left to right in figure).

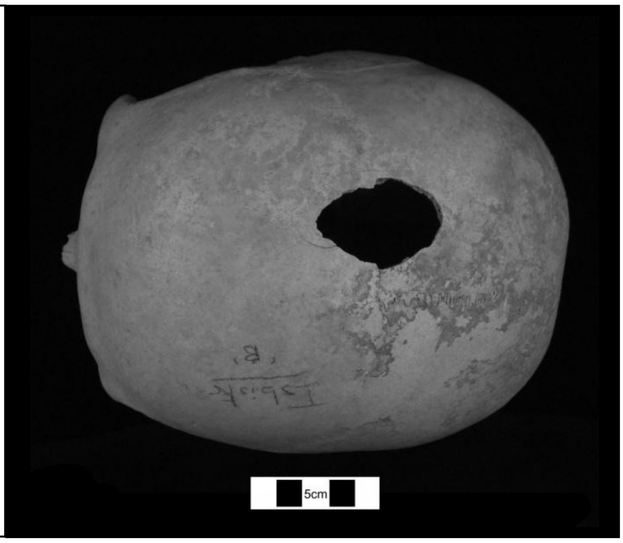


Figure 145. IS(1972) superior aspect. Blunt force trauma has punched out a disc of bone. Circumferential fractures exist anteriorly; posteriorly, these have been lost to subsequent taphonomic damage.

Figure 146. IS(1957), left lateral aspect. There is a circular incompletely penetrating wound to the left temporal squama posteriorly (circled). This is suggestive of a pointed weapon. (Note similarity with Rowiegar's ABDUA90046, Figure 187 below.)

Figures 144-146. Further examples of perimortem trauma from Isbister

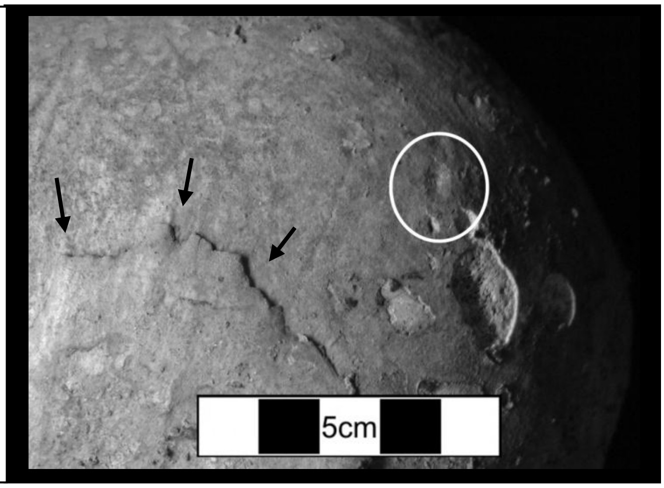
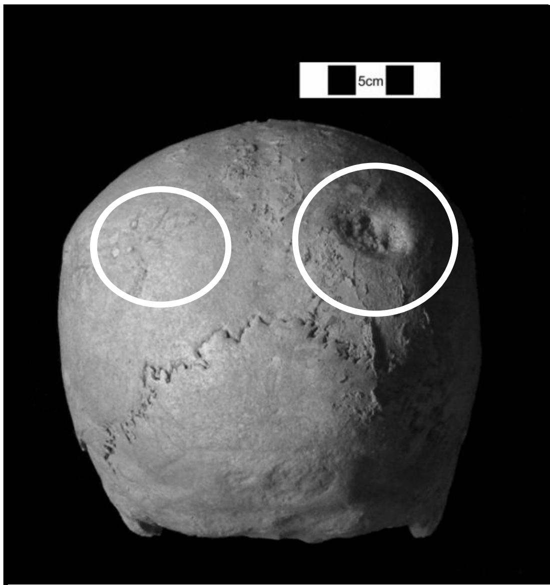
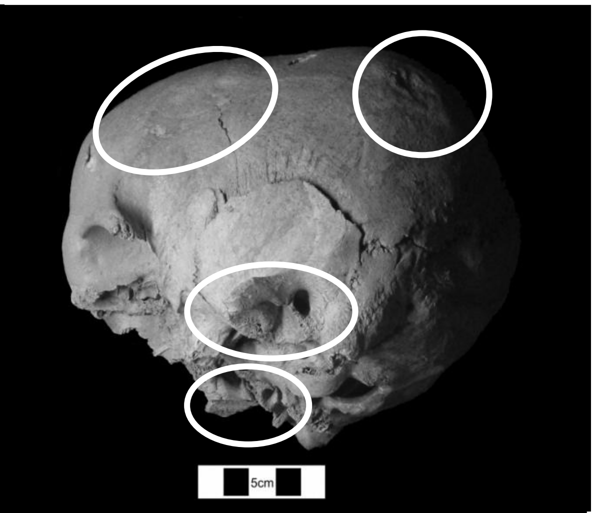


Figure 147. Cranium IS(2694), left lateral aspect, with healed blunt force trauma posteriorly (circled) but note the lipping of the squamosal suture (left of picture, arrows), which may indicate healed lateral trauma.





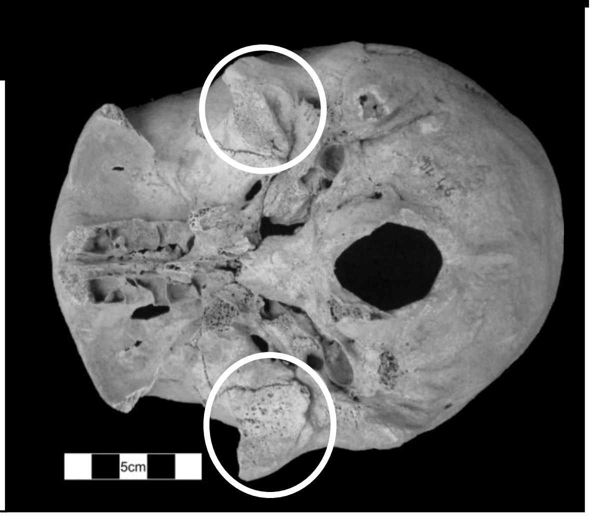


Figure 148. IS(1973), posterior, inferolateral and inferior views. Multiple healed vault fractures and bilateral OA probably secondary to mandibular subluxation.

Figures 147-148. Examples of healed cranial trauma from Isbister

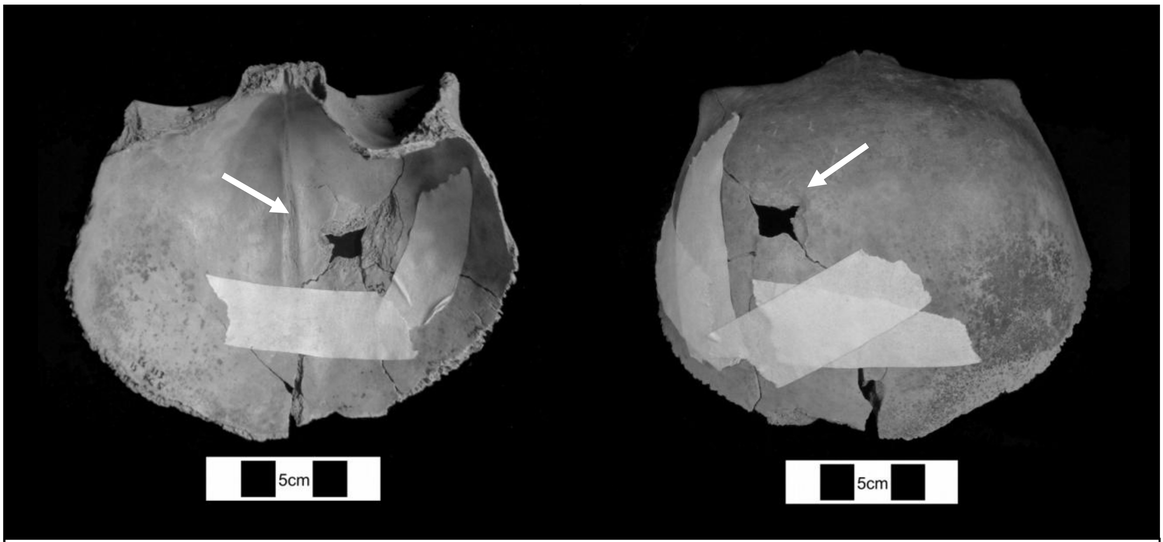


Figure 149. IS(7210) (left: endocranial, right: ectocranial) appears to exhibit a squarish lesion with radiating fractures and endocranial bevelling. Apparently a clear perimortem wound, the problem is that this cranium retains 20% collagen and is so tough that it might present any insult as perimortem. Patination suggests that the wound occurred in antiquity but we cannot determine when. Although no other cranium had this much collagen and all others were more fragile, if preservation is possible to the degree exhibited in this case then the decay of collagen in other bones may not have been rapid and this introduces uncertainty regarding the timing of fractures relative to death.

Figure 150. IS(2640) has a lesion superior on the right orbit margin. Its pale colour suggests that this is modern damage but the borders of the cut are porotic and consistent with healing or infection: This appears to be a cut suffered during life.

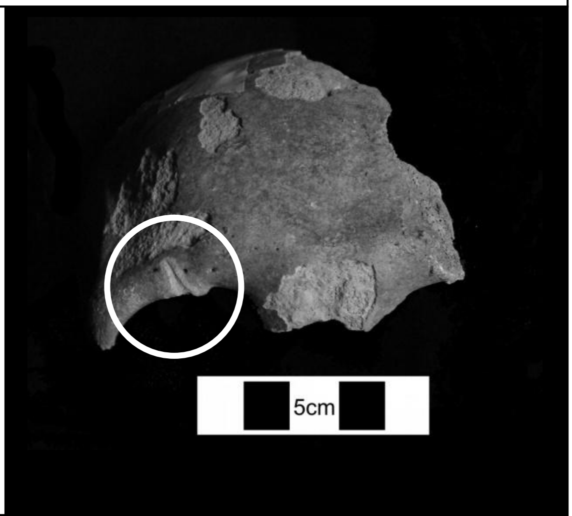
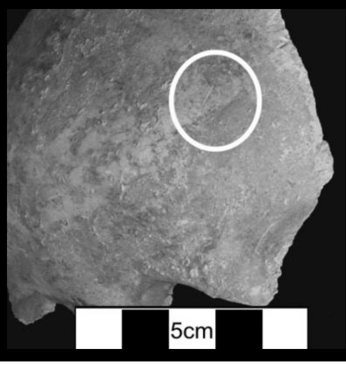


Figure 151. IS(7115), left anterolateral aspect. Another cut that appears sharp but is small and associated with scrapes. This is more likely to be an example of taphonomy.



Figures 149-151. Examples of problems in interpreting trauma.

Table 152. Locations of Primary Traumatic Cranial Lesions in Isbister Crania.							
	Left side			**Superior**	**Right side**		
	anterior	**lateral**	**posterior**		**anterior**	**lateral**	**posterior**
Healed	2	1	2	1	0	1	1
Perimortem	7	5	1	2	2	2	1
Uncertain	5	0	2	0	2	1	0
Total	14	6	5	3	4	4	2
Grouped	25			3	10		
	Anterior: 18		Mid-cranial: 13		Posterior: 7		
Secondary radiating and concentric fractures (present in at least seven cases) have not been included in the tables; one other case not included is a possible *contrecoup* fracture secondary to a left frontal lesion.							

In one instance, a perimortem "ping-pong ball" fracture was identified. This lesion occurs in young juvenile crania, where the cranial bone is thin and relatively flexible, permitting indentation under force without breaking.

Table 153. Number of Sites Implicated in Contemporaneous Multiple Trauma Events.							
	Left side			**Superior**	**Right side**		
	Anterior	**Lateral**	**Posterior**		**Anterior**	**Lateral**	**Posterior**
Healed	1	1	1	0	0	0	1
Perimortem	4	2	0	0	0	1	0
Uncertain	0	0	2	0	0	0	0
Total	5	3	3	0	0	1	1

All the individuals with multiple traumatic lesions whose point of origin could be determined displayed involvement of the left side, especially on the frontal. There are three individuals with multiple perimortem wounds to the left anterior cranium. IS(7284) had perimortem wounds to both the left anterior and right lateral areas, possibly indicating *coup-de-grace* following a stunning blow delivered face-to-face.

Table 154. Cranial Sites Involved Together (number of individuals).					
	L Anterior	**L lateral**	**L posterior**	**R lateral**	**R posterior**
L anterior	3				
L lateral					
L posterior	*		H		
R lateral	1				
R posterior	*		*		
Superior		H			
H One individual had two healed lesions to the left posterior parietal and one had a healed left superior parietal lesion as well as apparent damage (crushing or subluxation?) at the left squamosal suture. * One individual had healed wounds to left posterior, right posterior and left anterior areas as well as a bilaterally subluxated mandible: the posterior wounds may have been delivered following a stunning blow anteriorly, face-to-face; this might also suggest an initial swinging blow delivered laterally to the point of the jaw or possibly a kick after the individual had fallen.					

Prevalence calculations are complicated by multiple trauma and positive identifications of lesions on disassociated elements. Crude determinations based on cranial zone numbers were inappropriate because condition, fragmentation and location needed to be accounted for (e.g. including the petrous parts of the temporal was misleading; small frontal fragments were identifiable as different individuals but unlikely to be affected by trauma). Counting multiple lesions as 1, suggests crude prevalence of about 23% but possibly 40% when adjusted for surface condition and fragmentation factors to estimate complete crania equivalents (the overall prevalence estimate in Table 155 may be inflated by double counting from fragmented crania).

Table 155. Location Prevalences of Primary Traumatic Cranial Lesions in Isbister Crania.

	Left side %			**%**	**Right side %**		
	Anterior N=57(50)	**Lateral N=46(33)**	**Posterior N=49(35)**	**Superior N=49(42)**	**Anterior N=57(49)**	**Lateral N=48(34)**	**Posterior N=51(38)**
Healed	3.5(4)	2.2(3)	2.0(2.9)	2.0(2.4)	0	2.1(2.9)	2.0(2.6)
Perimortem	7.0(14)	10.9(15.2)	2.0(2.9)	4.1(4.8)	3.5(4.1)	4.2(5.9)	2.0(2.6)
Uncertain	8.8(10)	0	4.1(5.7)	0	3.5(4.1)	2.1(2.9)	0
Total	19.3(22)	13(18.2)	8.2(11.4)	6.1(7.1)	7.0(8.2)	8.3(11.8)	3.9(5.3)
Grouped	23.5(40)			3.5(6)	11.8(20)		
Overall n=85(50)	36.5(62)						

Figures in brackets are prevalence estimates based on good completeness and surface condition, omitting areas unlikely to be exposed to trauma from calculations. Multiple lesions in any region(s) are counted as one for that calculation to indicate MNI prevalence.

Although some recorded lesions may have been caused by accidents, face-to-face violence seems to have been endemic. Form and location of the wounds suggests use of weapons: penetrating wounds support this. The superior cranium and right posterior region were least affected and it is notable that one of the right posterior lesions was part of an extensive group of traumas. The viscerocranium may have been affected but was rarely sufficiently well preserved for adequate assessment. Only one mandible from Isbister (Figure 152) was recorded with perimortem fracture. A small number of vertebrae exhibit lesions indicative of survival following trauma likely to have derived from interpersonal violence.

Figure 152. Mandible IS(6703), inferior aspect, showing possible perimortem fracture.

IS(7149) is a near complete seventh cervical vertebra. There is a lesion (initially thought a tool mark) anteriorly on the superior body surface (15mm laterally x 9mm anteroposteriorly x 6mm inferosuperiorly), penetrating halfway down the body and halfway in. The lesion comes to a distinct angle inferiorly with flat edges flaring to the superior surface and a trigonal point in the centre of the body. The exposed trabeculae appear thickened to form smooth faces laterally.

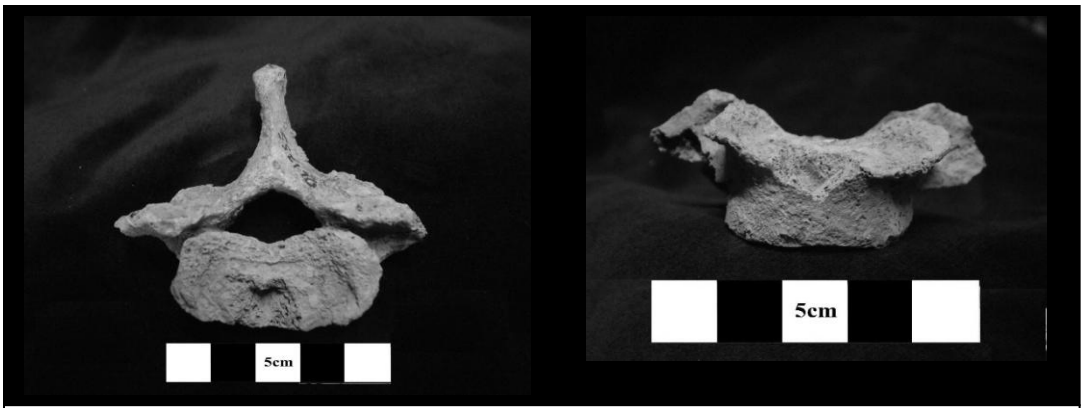
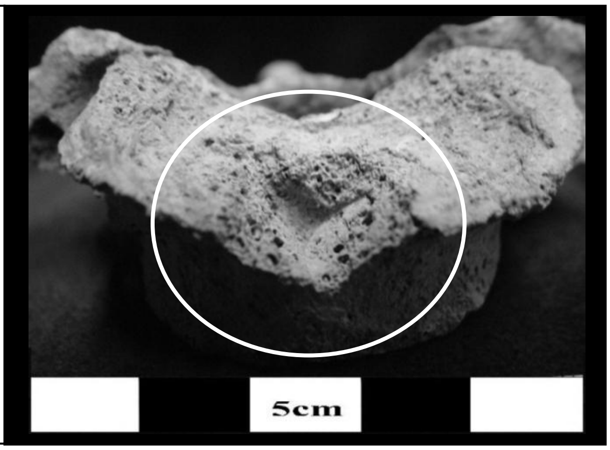


Figure 153. Thoracic vertebra IS(7149), superior and anterior aspects.

The most likely explanation for this lesion is a piercing anterior blow with an instrument such as an arrow, with destruction at the edges of the wound as the implement was withdrawn. The individual must have survived the immediate effects long enough for the trabeculae to remodel but not sufficiently for the wound to heal fully. Any such wound must have transfixed the thorax.

Figure 154. IS(7149): close-up view of the lesion shown in Figure 152.



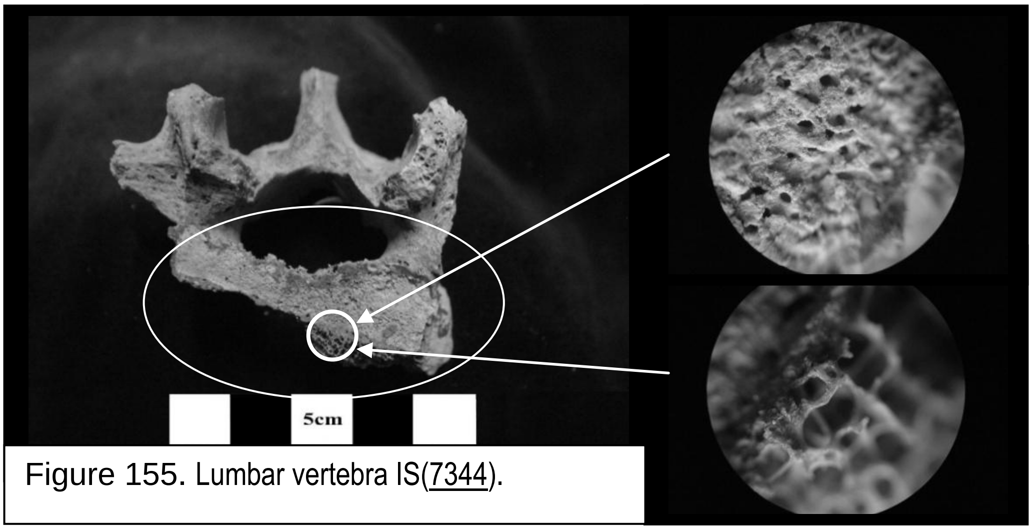
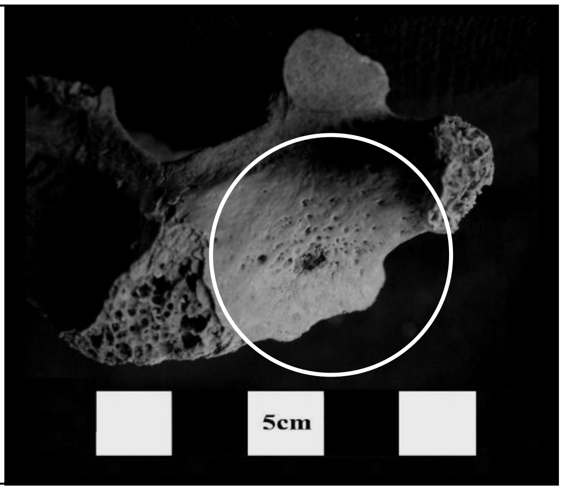


Figure 155. Lumbar vertebra IS(7344).

Lumbar vertebra IS(7344) (Figure 155) exhibits planar mechanical damage caused to the superior surface of the vertebral body, initially believed to be pseudopathology. Examination with a stereomicroscope indicated that the surface of the damage has the appearance of healing crushed trabeculae compared with the adjacent fractured surface. This may be an example of partly healed trauma from some instrument penetrating intervertebrally

IS(7327) is a thoracic vertebra distinguished by an area of porosity on the posterior surface of the right lamina (Fig. 156), indicating inflammation around a small area of mechanical damage. In life this area would be protected by thick muscle and such a lesion would most likely be caused by a penetrating wound.

Figure 156. Thoracic vertebra IS(7327), showing pitting posterolaterally, around a central focus.

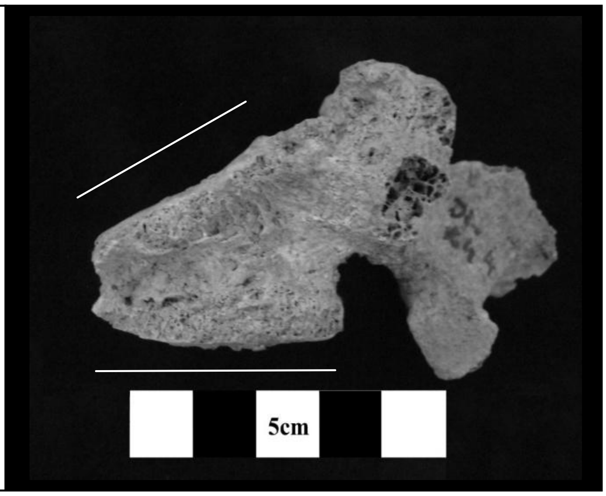


Vertebral Crush Fractures

There are four vertebrae from Isbister that exhibit crush fractures (with secondary DJD). These may be linked with osteoporosis or heavy labour as well as trauma events.

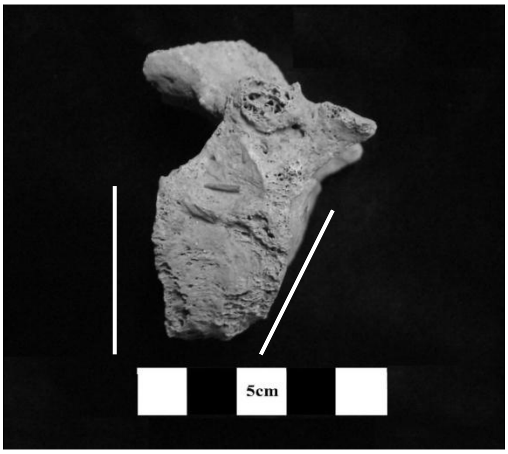
IS(7040) is an upper lumbar vertebra, probably the second. Both superior and inferior body surfaces are concave with Schmorl's nodes. The form of the body is wedge-shaped (Figure 157), with the anterior margin 12mm deep and the posterior margin 26mm deep on the left and 24mm on the right. There are small bone nodules, spicules and plaques peripherally around the body. Both superior articular facets exhibit degenerative remodelling. This is a clear example of crush fracture.

Figure 157. Crush fracture of lumbar vertebra IS(7040), left lateral aspect.



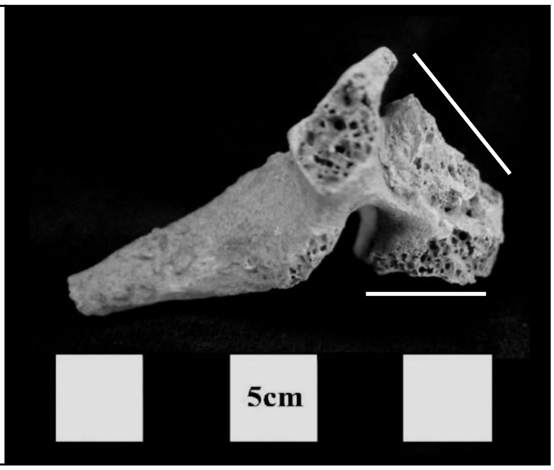
IS(7347) (Figure 158 below) is an eleventh thoracic vertebra with Schmorl's nodes in the superior surface of the body and minor ossification of *Ll. flavum*. The intervertebral facets appear normal but the costovertebral facets are exceptionally large (up to 14mm across) and deeply concave due to peripheral lipping. The superior part of the neural spine consists entirely of porous woven bone, patches of which occur widely on this element. There is some evidence of new bone anteriorly but much of this margin is damaged. The wedge-shape of the body, which is 15mm high anteriorly but 25mm posteriorly, is indicative of a crush fracture; other degenerative features may be secondary.

Figure 158. Crush fracture of thoracic vertebra IS(7347), right lateral aspect.



IS(7148) is a thoracic vertebra. The body is wedge-shaped with an anterior height of 12mm compared to a posterior height of 17mm. This is a clear crush fracture. The intervertebral and left costovertebral facets are eburnated and the remaining facets exhibit DJD. The superior body surface is heavily pitted.

Figure 159. Crush fracture of thoracic vertebra IS(7148), right lateral aspect.



IS(7343) is a vertebral body, probably mid-thoracic, with lipping on the right anterior border, both superiorly and inferiorly; both surfaces are heavily pitted. The body is wedge-shaped with an anterior height of 10mm and a posterior height greater than 17mm (Figure 160). This is a crush fracture featuring degeneration of the vertebral body and reactive lipping to stabilise the joints.

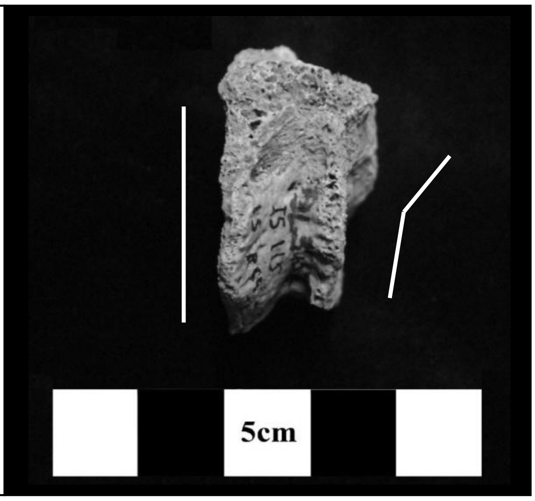


Figure 160. Crush fracture of vertebra IS(7343), right lateral aspect, possibly indicating anterior displacement of adjacent vertebra.

There is no indication of the number of individuals involved with such fractures. No vertebra is duplicated in the series but it is likely that several individuals were implicated. This would imply a widespread problem in the population, consistent with either the heavy labour or high prevalence of trauma exhibited in other elements.

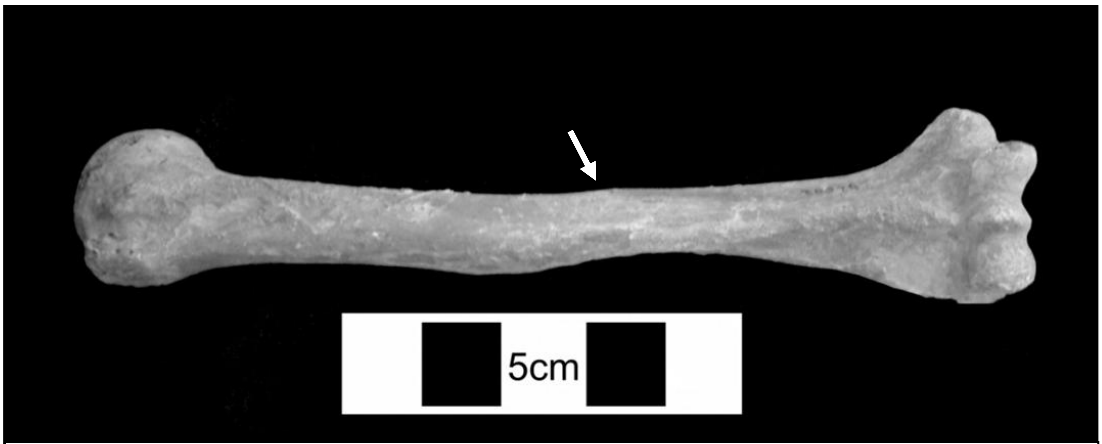


Figure 161. Apparently dysplastic humerus: possible well healed midshaft fracture but there is no definitive indication and the form may be affected by muscular development.

Examples of trauma recorded from Isbister in the upper limb were limited to the radius and manus. A single spiral fracture of a humerus was recognised (Rebecca Crozier pers. comm.) but a pale fracture surface suggests it may be from modern damage. One possible case (Figure 161 above) was so well healed as to be uncertain and potentially resulted from some other dysplasia.

IS(2098) is a distal fragment 159mm long, from a right side adult radius. There is a broad low nodule on the anterior diaphysis that may indicate soft-tissue trauma to *M. pronator quadratus*. A slight angulation of about 5º anteromedially at midshaft is associated with a lateral swelling (arrow in Figure 162 below). The abruptness of this angulation suggests that it is a callus, indicating a well-healed transverse, oblique or spiral fracture.

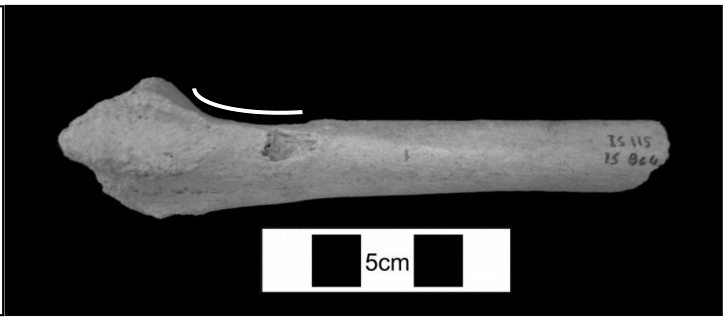
Figure 162. Right radius IS(2098), anterior and lateral aspects.

IS(3649) is a right distal radius fragment. The diaphysis is distinguished by a posterior displacement of the distal 30mm, resulting in a spoon-shaped profile (Figure 163 below). There is no apparent disruption to the bone surface, indicating that close apposition was maintained. This formation is indicative of a well-healed Colles’ fracture.

Figure 163. Left radius IS(<u>3649</u>), showing healed fracture: medial and anterior aspects.

IS(<u>5165</u>) is a distal radius fragment. The distal end is displaced posteriorly, forming a shallow spoon-shaped longitudinal profile (Figure 164 below). There is a slightly nodular ridge marking the superior boundary of the displaced part, forming an inverted ‘V’ with its apex on the medial diaphysis. Posteriorly, there is porotic remodelling along the margin of the articular surface and through the sulci and tubercles. This is provisionally interpreted as a well-healed Colles’ fracture, with good apposition.

Figure 164. Left Radius IS(<u>5165</u>), showing spoon-like dysplasia.



IS(<u>3679</u>) is a right distal radius fragment (Figure 165 below). The distal diaphysis has a slight convexity anteriorly, with retroversion of the diaphysis inferiorly: an oblique margin is apparent. There is a spoon-shaped longitudinal profile typical of Colles' fracture, in this case, associated with a proximal anterior displacement of the distal fragment. Close apposition and alignment were maintained, permitting good healing, and this may have been a greenstick fracture rather than Colles' fracture proper.

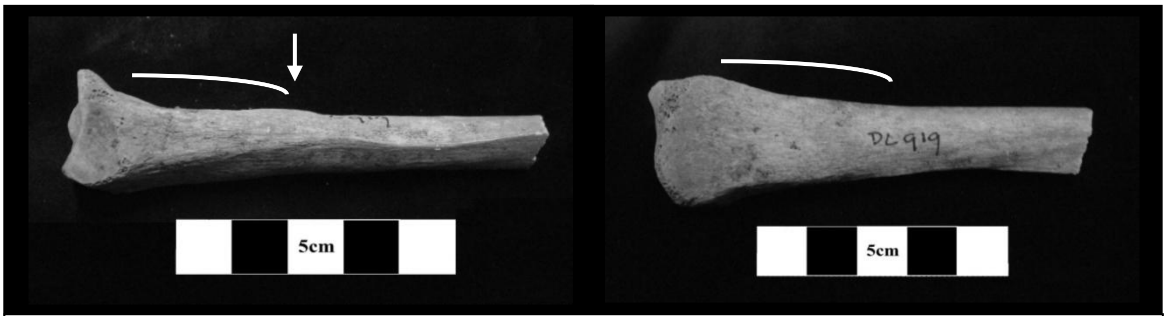


Figure 165. Right radius IS(3679), medial and anterior aspects.

IS(3638) is a distal right radius fragment. The distal epiphysis is grossly dysplastic, exhibiting avulsion of the styloid process: its location has a smooth surface showing eburnation, perpendicular to the diaphyseal axis. Separate anterior and posterior concave facets had formed above the normal articular surface, the posterior example being highly porotic with osteophytes along the posterior margin (Figure 166 below). These features are indicative of trauma to the wrist joint with subluxation of the carpus featuring extrusion of the proximal carpal row and realignment of the distal row with the radius. The scaphoid may have been fractured. Fracture across the styloid process appears to have created a pseudarthrosis. This has caused remodelling and led to secondary osteoarthritis.

Figure 166. Right radius IS(<u>3638</u>),
a) distal aspect, showing remodelled surface.

b) Anterior aspect showing avulsion of the styloid process.

A single radius appeared to exhibit a healed proximal fracture (Figure 167).

Figure 167. Well healed proximal fracture of radius, showing angulation.

<u>Summary Of Trauma in the Radius</u>

The most likely aetiology of these lesions is, in each case, traumatic injury caused by a fall broken by the outstretched hand. Sudeck’s atrophy is a common complication of such injuries, featuring tenderness, osteoporosis and restricted use of the fingers, hand and wrist (McRae 1994:178). Well-healed appearances suggest that the ulnae may not have been implicated or that there was splinting; no examples afflicting the ulna were recorded. Four examples are right side, compared with only one left, which could relate to handedness.

Manual Trauma

IS(6547) is a right fifth metacarpal. The diaphysis is dysplastic with ‘ragged’ surfaces (Figure 168). There is lateral angulation of about 10º and palmar displacement of the distal element by 2mm, probably associated with overriding of an oblique fracture surface. The dorsal surface exhibits discontinuity near the proximal epiphysis. There is a slight axial rotation between the two elements, the distal epiphysis has 10º medial rotation relative to the proximal – the little finger will have been angled away from the others of that hand. This is a healed case of a spiral (or possibly oblique) fracture, typically caused by shearing forces whilst delivering an unskilled blow with a clenched fist, or by twisting of the little finger (Dandy 1993:224).

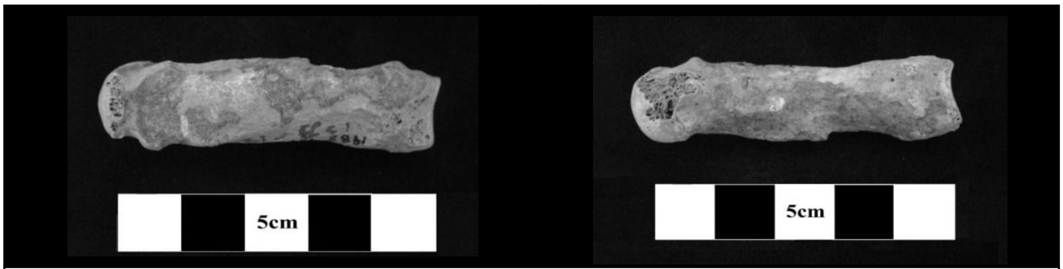
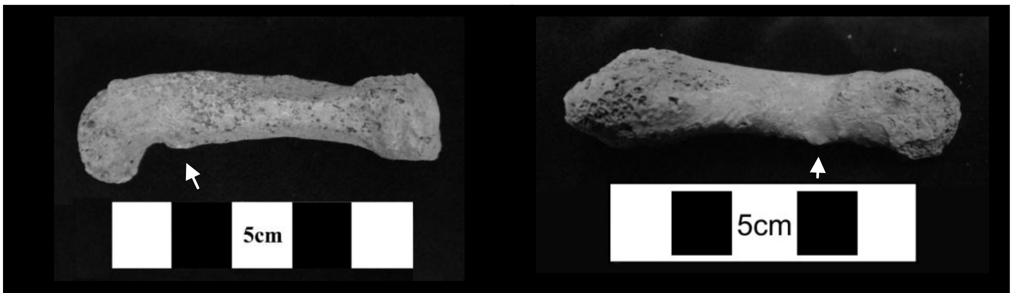


Figure 168. Metacarpal IS(6547), dorsal and lateral aspects.

Fractures were also recorded from IS(5594) and (6278), also right fifth metacarpals (Figure 169), and metacarpals identified at NMS (Figure 170).



IS(6278), lateral aspect; IS(5594), palmar aspect

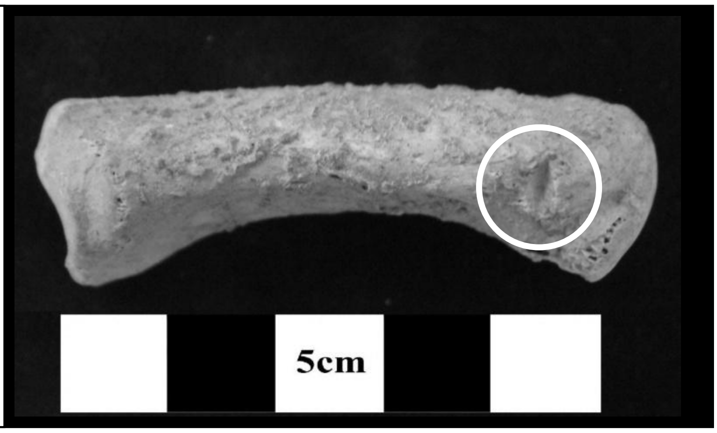
Figure 169. Metacarpals with Well Healed Fractures.

Figure 170. Healed carpus fractures in the Isbister collection at NMS

Healing of carpal fractures is aided by support from neighbouring bones and a large area of apposition between the fracture surfaces. The right side was most affected, as with the radius. This may indicate handedness and activity-specific injuries such as interpersonal violence.

Left first metacarpal IS(5055) may have a chop mark laterally but this is more likely to be a residual element from a pseudo-epiphysis (circled in Figure 171).

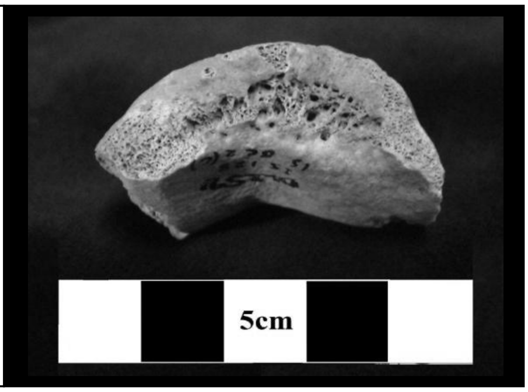
Figure 171. Metacarpal IS(5055), lateral aspect.



Lower Limb Trauma

IS(3737) is a left patella in good condition but with some marginal mechanical damage. This element is the larger part of a bipartite patella, formed by a fracture in the sagittal plane. It is likely that the bipartite nature was traumatic in origin because although the margins are rounded and well-healed, the trabeculae are still exposed and have not yet completely remodelled (Figure 172). There is no indication of any secondary degenerative condition associated with this, nor are there any enthesophytes suggestive of particular strain.

Figure 172. Bipartite (emarginate) patella IS(3737), medial aspect.



IS(3746) is a right patella in good condition with some inferior marginal mechanical damage and moderate mineral concretions. A smooth edged angular hole 6mm x 6mm x 4mm deep in the superior margin, immediately superior to the vastus notch may be a tool mark (Figure 173, circled) but has apparently healed exposed trabeculae. If this is the result of an injury suffered during life then the knee must have been flexed to expose the damaged area.

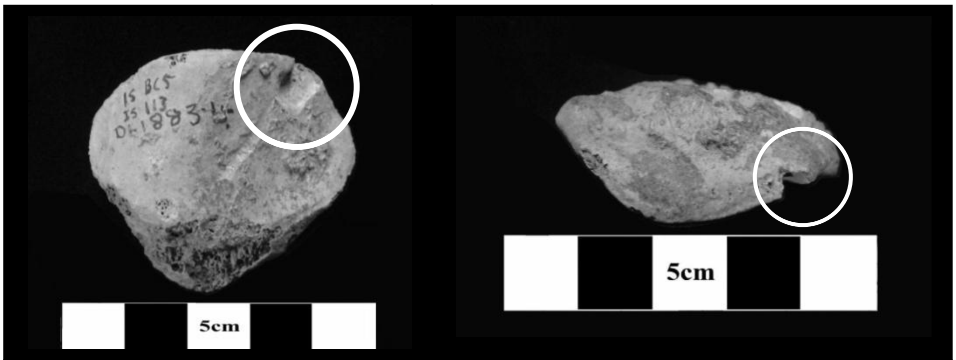


Figure 173. Patella IS(3746), posterior and superior aspects.

IS(6593) is a 98mm long distal fragment of left tibia that has been sawn across the diaphysis proximally. The distal extreme of the diaphysis is abruptly displaced posteriorly indicating a fracture healed at an angle of approximately 5º with nearly 100% apposition. This near normal alignment and the well-healed nature of the lesion suggest that this is the result of a green-stick fracture in youth. The fibula is likely to have been damaged simultaneously. There appears to be an anteromedial callus cut by the sawn surface (right in Figure 174) probably from the original radiocarbon dating project sampling), where the bone surface overlies a trabecular band, itself overlying cortical bone.

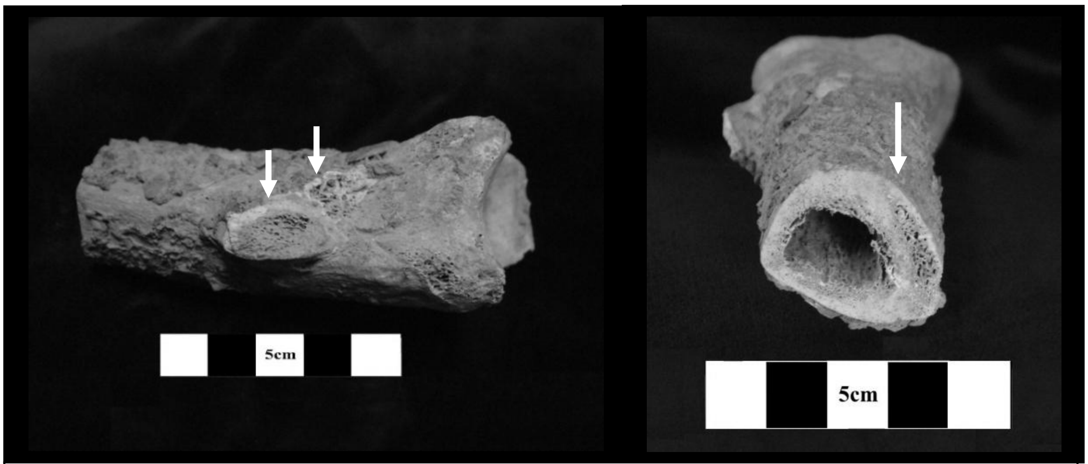


Figure 174. Tibia IS(6593), lateral and proximal aspects.

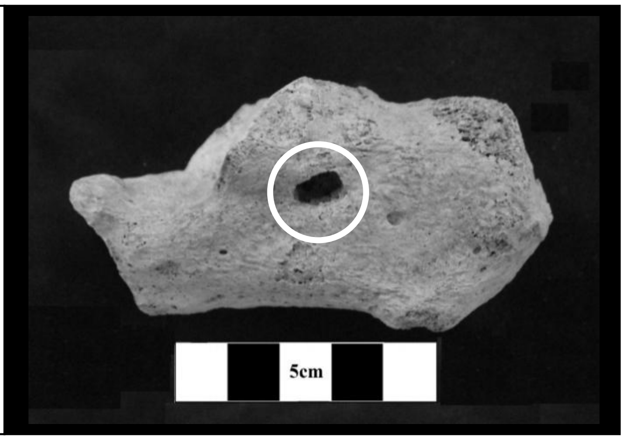
Two trabeculated bone growths appear laterally, superior to the fibular notch (left in Figure 174). These appear like osteochondromas but are probably myositis ossificans associated with the fracture. The fibula will have been affected but was not identified in the collection.

IS(5880) is a right calcaneus. The lateral surface is markedly rugulate in appearance due to widespread striate cortical bone. There are medium enthesophytes for *T. Achilles* laterally and slight anterior lipping on the posterior talar articular surface. The sustentaculum tali is expanded to a thickness of 15mm posteroinferiorly creating a distinct groove posterior to the articular surface. There is a band of bone on the medial surface, attached along the inferoposterior margin of the sustentaculum tali and inferiorly across the medial surface of the calcaneus to form a flange (circled, Figure 175). The anterior surface of this 'flange' is smooth but has been lost to modern damage posteriorly. This bone occludes the passage of *M. flexor hallucis longus* and probably results from ossification following a tear across this muscle. This injury will have prevented normal use of the ankle, probably affecting gait.

Figure 175.
Calcaneus IS(5880), medial aspect showing enthesis.

IS(5886) is a left calcaneus. A subrectangular feature 9mm anteroposteriorly x 5mm superior-inferiorly appears as a fistula in the lateral surface 10mm posterior to the posterior talar articular facet. Within the bone, was a space-occupying lesion that formed a rounded void larger than the surface orifice and 9mm in depth (circled, Figure 176). Inside the bone, the trabeculae are remodelled into a smooth surface around much of the lesion and are smooth and thickened elsewhere, indicating either a healed or a slow-growing lesion. The edge at the cortical surface is sharp and approximates a right angle with a slight overhang and little indication of any roundedness. There is slight spicule formation describing a narrow arc running in a crescent from immediately beneath the lesion, posteriorly for approximately 12mm and curving back to the superior edge of the lesion, possibly from soft tissue damage. Striate and porous woven bone were deposited inferolaterally.

Figure 176. Calcaneus IS(5886), lateral aspect, showing lesion (circled).

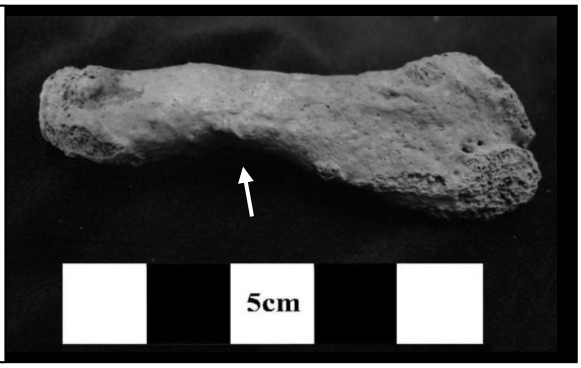


This lesion is distinct from neoplastic conditions. The rectangular ‘fistula’ is suggestive of a penetrating wound but does not have the rounded appearance of a cloaca.

Trauma in the Metatarsals

IS(5600) is a right fifth metatarsal with a thickened and irregular diaphysis in which the distal end is angled about 5º laterally and rotated about 30º plantarly, giving the head a vertical attitude (Figure 177 below). Both head and shaft have numerous rounded nodules but are well remodelled. This appears to be a well-healed oblique fracture that may have been associated with soft tissue damage. Apposition remained close but rotation and displacement of the distal element may have deformed the foot and caused ambulatory difficulties.

Figure 177. Metatarsal IS(5600), plantar aspect.



IS(3822) is an adult left fifth metatarsal with a 5º angularity midshaft, associated with a linear disruption to the surface. Slight localised concavity dorsally is echoed by convexity of the plantar surface. The linear disruption is slightly nodular laterally and a patch of woven bone 6mm in diameter occurs distally on the dorsal diaphyseal surface (upper part Figure 178). Although the head is mostly lost, its surviving surface displays fine porosity plantarly. This is provisionally interpreted as a healed oblique fracture.

Figure 178. Metatarsal IS(3822), dorsal (above) and plantar (below) aspects.

IS(3600) is a right first metatarsal with several dysplastic features (Figure 179 below). The head is displaced plantarly and laterally with the loss of the full articular surface superiorly and medially. There is an area of porotic bone distally on both the medial and lateral surfaces of the diaphysis and a flattened nodule 14mm long x 5mm wide raised 4mm from the mediosuperior distal diaphysis. There is an apparent 16mm x 12mm concave attachment facet laterally on the proximal diaphysis. There is an area of eburnation on the plantar aspect of the head one on the central ridge and slight joint expansion on the posterior margin of the plantar head surface. This is clear osteoarthritis and may have been caused by hyperflexion of the proximal phalanx. The dysplastic nature of the head and the contact facet suggest a traumatic origin with collapse of the distal epiphysis and displacement of the proximal articulations of the tarsometatarsal joints resulting in the tendon for *M. peroneus longus* attaching at an unusual site with an enlarged facet. The distal nodule may be the attachment for an accessory branch of the *M. extensor hallucis longus*.

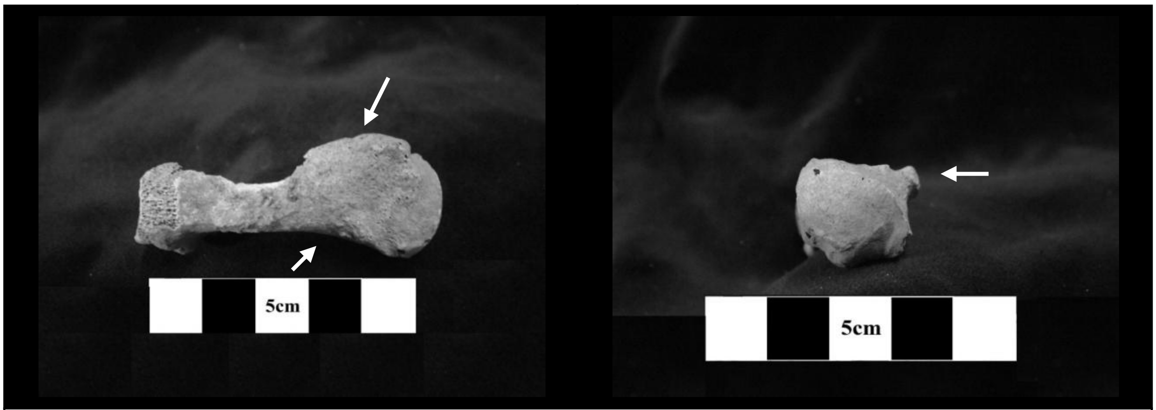


Figure 179 . IS(3600), dorsal (left) and anterior (right) aspects: angulation and nodule.

Figure 180. IS(3490), a right first metatarsal: healed fracture with laterally displaced angled head.

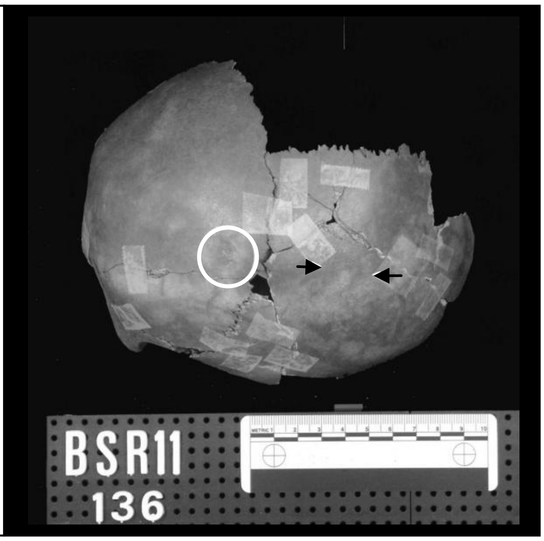
Figure 181. IS(4887), a left fifth metatarsal with a healed fracture associated with evidence of inflammation proximally.

These five fractures are limited to the first and fifth metatarsals, which probably relates to their greater exposure and limited support. Fractures of this element may be from direct trauma or fatigue due to repeated stress. Porosity of the metatarsal head is not uncommon in this population (Table 148, pp291-292 above) and may relate to a degenerative joint condition, possibly secondary to trauma, especially since few individuals exhibit advanced age at death.

Trauma at Banks

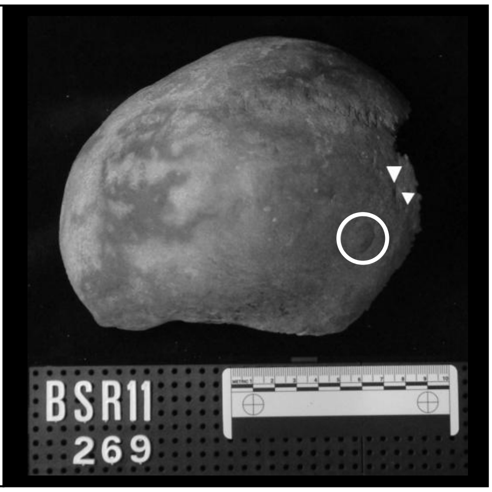
There are few examples of trauma from Banks, none is obviously perimortem. The only clear cranial example is on the superior frontal of a juvenile aged about 4 years old at death (BSR(244), Figure 182 below). This is well-healed, showing that the individual survived the incident. The cause cannot be ascribed with any certainty but it is worth noting that most accidental cranial trauma today usually affects the so-called hatband area of the cranium (Kremer *et al*. 2008, Guyomarc'h *et al*. 2010, Fracasso *et al*. 2011). This lesion lies superiorly, which could indicate interpersonal violence: the location is consistent with a downward blow delivered face-to-face, although for a young child, an adult might hit this position from any attitude and trauma might have occurred through falling. This cranium has an ephemeral linear mark antero-posteriorly high on the left parietal, which appears to be a cut but that may be a taphonomic scratch: it was too fine for a clear determination but the entire surface of this cranium exhibits fine taphonomic scratching when examined under low magnification.

Figure 182. Juvenile cranium BSR(244), exhibiting healed trauma (circled). There is a possible cut (marked by the two arrows) but this is likely to be taphonomic.

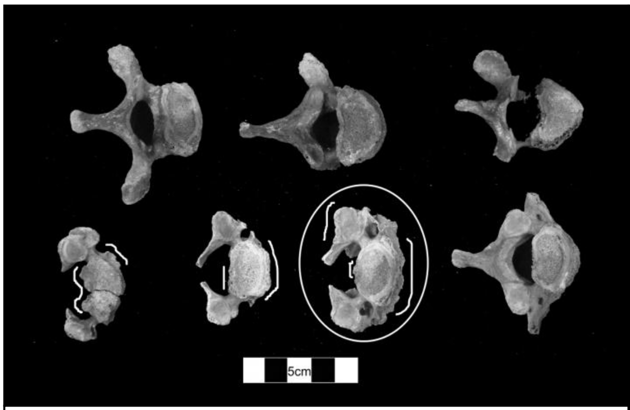


A second possible example of cranial trauma was on BSR(001) (Figure 183). This is a subtle circular lesion and may be a well-healed haematoma or an osteoma. If this is an example of trauma, then the site would be consistent with either an accidental cause or violence. In close proximity to this lesion are two small depressions in the bone that could be healed traumatic lesions or cortical defects.

Figure 183. Adult cranium BSR(001), exhibiting possible trauma (circled and arrowed).



Trauma is inferred by a healed cervical crush fracture in vertebrae BSR(1399)-(1410), shown in Figure 184 (below). This individual was adult at death but the age when the trauma occurred is unknown. The most common cause in modern medical practice, after car accident 'whiplash,' is a blow to the top or back of the head (Salter 1983:508; McRae 1999:213). In this instance, the directly affected vertebrae are the 4th and 5th cervical vertebrae, which have fused in a wedge shape. Such fractures are stable but may incur neurological problems if disc tissue is forced into the spinal canal. Following the insult, this individual will have had an obviously bowed neck and may have had difficulty in moving the head. The individual survived for many years since the lesion is well healed and has led to secondary osteoarthritis. Secondary degenerative joint disease in the adjoining bones is extensive and probably related to mechanical disadvantage in head posture. This is reminiscent of features noted above (pp11 and 13).



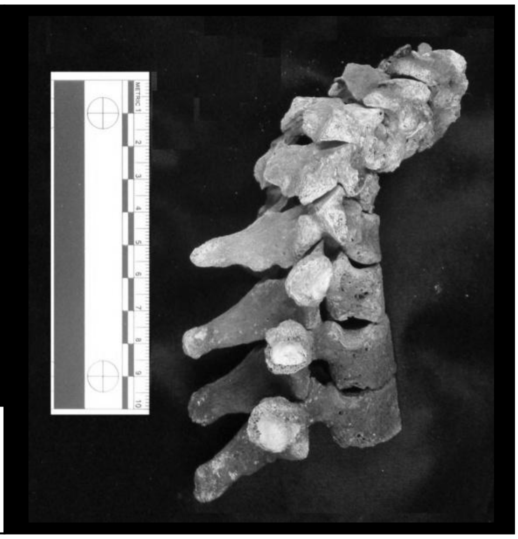
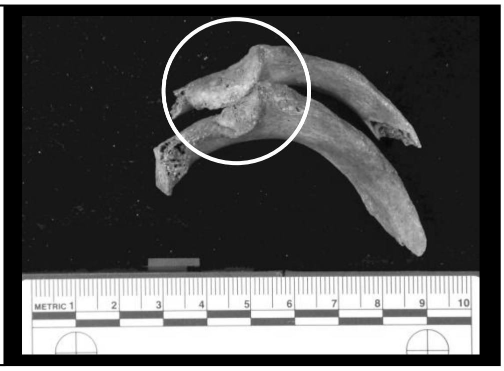


Figure 184. BSR(1399) -(1410): cervical crush fracture and secondary DJD (lipping outlined).

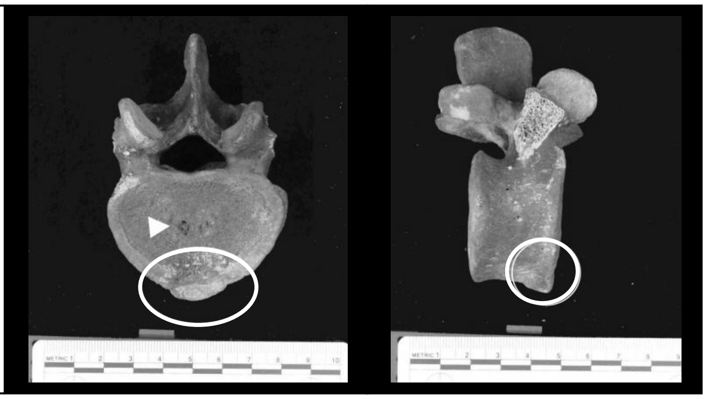
Trauma is also inferred from a lesion affecting two conjoining adult right ribs (BSR(1454) and (1455), Figure 185). These display an extensive deposition of bone peripheral to the tubercles. This has formed virtually a single surface from both ribs at this point and is probably a case of osteoarthritis secondary to thoracic trauma. The articulating thoracic vertebrae (and possibly neighbouring ribs, the sternum and soft tissues) would be expected to be implicated and the individual may have suffered from stiffness and pain that could have inhibited breathing and mobility. No other associated bones were identified however.

Figure 185. Ribs BSR(1454) and BSR(1455): adjoining ribs with osteoarthritis (circled).



Another lesion with a likely traumatic origin is on adult lumbar vertebra BSR(953). This exhibits a healed dysplasia that consists of an interruption to the superior body margin anteriorly, with a small volume of bone extending anterior to the expected curve. This is unlikely to be a case of spondylolisthesis because the area involved is too limited to accommodate slippage of another vertebral body. It is most likely to have been caused by an avulsion of part of the bone, which has then healed in a slightly displaced location (Figure 185, circled). There is no indication that there was any vertebral disc involvement but neither can this be certainly discounted. This vertebra also has a small Schmorl's node on the superior surface (Figure 186, arrowed).

Figure 186.
Vertebra BSR(953). Left, superior aspect; right, right lateral aspect. Arrow: Schmorl's node; circle: healed avulsion.



It is possible that two or more of these cases came from a single adult that had suffered either a major accident such as a fall from height or a sustained assault. All examples were well healed.

The cranium of a juvenile aged about 9-10 years at death BSR(146) has a markedly asymmetric cribriform plate (Figure 187, centre), possibly caused by some pathological condition or trauma. Examination under low magnification reveals bone abruptly ending with surfaces patinated identically to the surrounding bone. This is a location unlikely to have been damaged taphonomically in antiquity. There is no evidence anywhere of healing, inflammation or reactive bone deposition, except for perinasal pitting and cribra orbitalia, both of which are probably unrelated results of disease or dietary insufficiencies. The condition is most likely to have been a perimortem fracture caused by a high velocity blow involving some perforating instrument - falling on some object aligned with the nasal passage for example. The same cranium has a remarkably straight-edged fracture inferosuperiorly along the frontal process of the right maxilla, which may indicate a perimortem facial injury, potentially implicated as part of the same insult, possibly with telescoping of a bone fragment into the cranium, although the superior parts of the nasals remain in position and cartilage would not be expected to create such a fracture (Figure 186, circled: left shows the profile clearly).

Figure 187. Cranium BSR(146), lateral and endocranial aspects. The left side cribriform plate (circled, centre) has far less bone than normal. The anterior margin of the frontal process of the right maxilla appears to have a near vertical fracture (left and right) that may indicate an ancient cut or sharp force trauma (the damage to the left frontal process appears to be taphonomic).

Complications of such an injury had the individual survived the event could include anosmia, brain damage, leakage of cerebrospinal fluid and possible meningitis (if the wound becomes infected).

Cranial Trauma at Rowiegar.

The collections from Rousay are limited but perimortem trauma was recorded from the Knowe of Rowiegar.

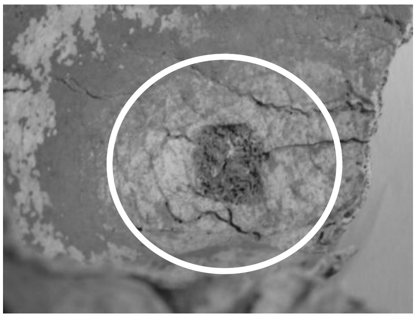
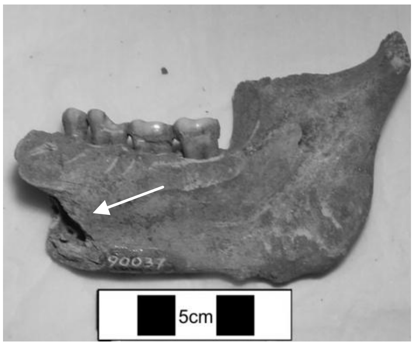


Figure 188. ABDUA90046, anterior, right lateral and endocranial views. Perimortem fracture, with endocranial bevelling.

One example is of a depressed fracture from an apparently pointed object, which occurs laterally on the right frontal of ABDUA90046 (Figure 188). This has caused endocranial bevelling and a radiating crack. There is also a fracture on the left frontal of ABDUA90035 superiorly (Figure 189, right), probably caused by blunt force trauma, possibly a second on ABDUA90057. A possibly perimortem fracture was recorded on mandible ABDUA90037 (Figure 189, left).

Figure 189. ABDUA 90037 and 90035: possible trauma.



Mandible ABDUA90037

Cranium ABDUA90035

Summary of Trauma

The large number of crania with fractures reflects (often deadly) interpersonal violence. Fracture form included circular blunt force trauma consistent with a direct mace blow or slingshot strike, linear and ovoid blunt force trauma consistent with clubs, weapon hafts or rocks, narrow penetrating trauma consistent with a pointed weapon such as a spear or arrow with a sharpened tip or an antler pick; and sharp force trauma consistent with a glancing axe. The multiple lesions of IS(7284) and IS(1973) particularly indicate close contact rather than missile attack, with IS(1972) probably being 'finished off' with a cluster of blows after being stunned: the shape of the anterior lesion implicating a blunt weapon with circular cross-section, whilst the lateral lesions suggest use of considerable force producing fractures of similar size and therefore all consistent with a single weapon. The stone fragment embedded in IS(7114) (Figure 142) might be taphonomic but, associated with a closely fitting endocranial hinged spall seems more likely to be part of a broken weapon, perhaps carved intentionally but possibly a weapon of convenience. The close similarity of the circular penetrating lesions in IS(1957) and ABDUA90046 (Figures 146 and 188), with peripheral crushing also seems more likely to derive from hand weapons, as do the examples of sharp force trauma (IS7280) and IS(2640) (Figures 144 and 150). Other blunt force trauma has punched out bone discs and sometimes split crania (e.g. IS(7207), Figure 141). Fractured or dislocated mandibles (IS(1973), IS(6703) and ABDUA90037: Figures 148, 152 and 189) however could equally result from empty-handed assault (consistent with observed metacarpal fractures) as armed attack.

The majority of longbone fractures observed seem, in contrast, consistent with an accidental origin. All those recorded were well-healed, which supports a distinction in aetiology from at least some cranial fractures. Radius fracture seems rather common (about 4% of right adult radii) and there is a greater prevalence of radius trauma to the right side than the left, as there is of distal DJD (Table 137, p278 above). This may imply that trauma relates to handedness, which might suggest that it does not occur only as a result of symmetrical activity but the sample of fractures alone is small and the difference in numbers is statistically insignificant. Perhaps more importantly, Colles fracture tends to occur in adults after the age of 40 years and is not common in youth (Adams 1962:139-140). This would be consistent with an age-related element to some of the vertebral crush fractures recorded (pp317-319 above), whilst other cases of vertebral trauma (pp315-316 and pp334-335 above) are more likely violence related.

It may be significant that the right metacarpals also seem to have been more prone to injury than the left, including both trauma and enthesopathy but not DJD (Table 139, p279 above). The prevalence of fifth metacarpal fracture is highly suggestive of interpersonal violence, which supports observations on the crania but has no obvious direct relationship to trauma of the radius.